HIGH ENERGY SORGHUM SILAGES EVALUATED BY IN VITRO AND IN VIVO DIGESTIBILITY AT PARENT AND RATOON HARVESTS

A Thesis

by

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ABSTRACT

High Energy Sorghum Silages Evaluated by In Vitro and In Vivo Digestibility at Parent and Ratoon Harvests

(May 1985)

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A randomized split-split-plot design was used to analyze two sweet, Wray and Rio, two high energy, ATx623xRio and ATx623xWray, and two high grain, ATx623xRTx430 and ATx623x74CS5388, sorghum types harvested at 50% anthesis, soft dough and hard dough maturities for both parent and ratoon harvests. Dry matter yield (DMY), dry matter ensiling losses (DMEL), seepage, temperature, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), ash, in vitro dry matter digestibility (IVDMD), organic acids and ethanol were determined. Mean DMY increased ($P<.01$) with maturity but decreased ($P<.01$) from parent to ratoon harvest. Mean DMEL ($P<.05$), seepage ($P<.01$), temperature ($P<.01$), NDF ($P<.01$) and ADF ($P<.01$) decreased with maturity. However, temperature increased ($P<.01$) from soft to hard dough maturity. Mean DMEL ($P<.05$), seepage ($P<.01$) and temperature ($P<.01$) were lower and ADF higher ($P<.01$) at ratoon than at parent harvest. Mean ADL did not change with maturity but decreased ($P<.05$) from parent to ratoon harvest while ash increased ($P<.01$) with maturity and harvest. Mean IVDMD increased ($P<.01$) with maturity but did not change with harvest. Lactic and acetic acids decreased ($P<.01$) with increasing age and from parent to ratoon harvest. Small non-significant changes in ethanol content occurred as maturity advanced, but it increased ($P<.01$) with harvest. A simple change-over design with six steers was used to analyze in vivo digestibility in Wray, ATx623xRio and ATx623xRTx430 at hard dough maturity for both harvests. Mean ADF, dry matter intake (DMI), dry matter digestibility (DMD) and acid detergent fiber digestibility (ADFD) were determined. Differences among diets existed ($P<.01$) for ADF at both harvests and for DMI at parent harvest. Mean DMD and ADFD did not differ ($P>.05$) among diets at parent harvest. However, at ratoon harvest, DMD and ADFD were higher ($P<.05$) for ATx623xRTx430 than for ATx623xRio. In vitro and in vivo dry matter digestibility were correlated ($r= .989$). No significant responses were found in any silage measurement with a silage additive. High energy sorghums may satisfactorily be used for silage making.

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INTRODUCTION

Sorghums have long been an important silage, hay and grain crop in Texas because of their relatively low water requirements and drought resistance compared to other crops. There has been an increasing interest in developing new varieties and hybrids that would be more drought and insect resistant and also maintain and/or potentially increase their yield characteristics. Plant breeders have successfully developed high grain, sweet, and more recently high energy sorghums that could potentially increase sorghum productivity.

In 1980, Texas produced 2.3 million t of sorghum grain, or approximately 30.9% of the total production in the United States. After grain harvest, the remaining stover amounts to approximately 3 t/ha. With proper harvesting and storage, this could represent a considerable source of feed for growing and finishing cattle. Moreover, if the stover portion of the plant could be harvested with the same field operation as grain harvesting, this additional forage could be obtained with relatively little additional cost.

Changes in chemical composition occur throughout the growth cycle of any plant. Stage of maturity at harvest is one of the most important factors that affect the yield and nutritive value of the plant. It is necessary to evaluate

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The style and format of this thesis are those outlined by the Journal of Animal Science 53:845 (1981).

nutritive value in experiments involving plants of different maturities since value changes with maturity. The value of any livestock feed depends on many factors including palatability, intake, digestibility and metabolizability. Fiber content in grasses increases with advancing maturity concurrent with a depressed dry matter digestibility. However, in sorghums of high grain content and with sweet sorghums, crude fiber decreases as the plant matures because of a rapid rise in starches and sugars, respectively.

Sorghum hybrids have been developed through genetic selection to produce higher grain and forage yields. Selection has also resulted in new high energy sorghum hybrids with high levels of soluble carbohydrates in the stover combined with high grain and stover yields. Methods have also been developed to increase the number of harvests that can be harvested from a single seeding by harvesting ratoon harvest. Since sorghum plants have the ability to regrow after harvest, ratooning or multiple cropping represents a means to reduce production costs, such as land preparation and seeding cost.

In the near sub-tropical regions of Texas, ratoon cropping represents an improved potential for livestock feeding programs. Since ensiling represents one of the most efficient ways of handling and harvesting forages for livestock, these new high energy sorghum hybrids offer potential as silage in cattle feeding programs. However, very limited information regarding their preservation and feeding value for beef cattle production is available.

OBJECTIVES

The specific objectives of this research were:

1) To determine changes in dry matter yield, ensiling characteristics and losses, chemical composition and in vitro dry matter digestibility of four hybrids and two varieties of sorghum silage harvested at 50% anthesis, soft dough and hard dough stages of maturity at both parent and ratoon harvests.

2) To establish in vivo dry matter and acid detergent fiber (ADF) digestibility of one grain sorghum hybrid, one high energy sorghum hybrid, and one sweet sorghum variety for both parent and the first ratoon harvests at the hard dough stage of maturity.

LITERATURE REVIEW

Silage results from the anaerobic preservation of moist forage or other feedstuffs by the formation of organic acids, and represents one of the most efficient ways of harvesting and storing forages and green crops for livestock. Reduced weather damage at harvest, total mechanization, higher nutrient yield per hectare, and improved feeding programs are the major advantages of silages compared to alternatives.

The importance of sorghums in cattle production is unquestioned since sorghums have constituted the basis of cattle feeding programs of the Southern U.S. where they are highly dependable crops. Sorghums represent a widely used silage crop in both dairy and beef cattle feeding.

Chemical Composition

Recently, new high energy sorghums have been bred to increase total biomass yield (> 21,000 kg/ha) without reducing grain yield compared to grain hybrids (Miller and Creelman, 1980). They have described these new hybrids as about 1.5 to 2.5m tall, with high grain yields (>5000 kg/ha) and sweet stalks which contain high level of soluble carbohydrates. Data of Miller and Creelman (1980) also show that high energy sorghums are substantially superior in production of total carbohydrates than sorghums with only sweet stems. In fact, ATx623 x RIO, a high energy hybrid, had a total carbohydrate yield of 9906.26 vs 7631.87 and

6393.11 kg/ha for Rio and Wray, respectively. Limited data are available to indicate their ability to ensile or to establish nutritional value when fed.

Nitrogen-free extract (NFE) increased while crude protein and fiber decreased from heading to the ripe-seed stage in sorghums (Vinall et al., 1924). Webster and Davies (1956) reported that with increasing maturity, from milk to hard-seed stages, NFE in sorghum increased rapidly, with a relative decrease in crude fiber, protein and ash due to increased starch deposits in the seed. Hibberd et al. (1981) reported that the concentration of starch and ash in grain sorghums were very similar for 35 d prior to maturity. Danley and Vetter (1973) pointed out that the forage constituents most affected by advanced maturity were protein, lignin, and soluble and structural carbohydrates. Total nitrogen and soluble carbohydrates declined while cellulose, hemicellulose and lignin content increased as the plant matured (Waite, 1963). Data of Danley and Vetter (1973) showed increases ($P<.01$) in dry matter and hemicellulose and decreases ($P<.01$) in crude protein and estimated total digestible nutrients with advancing maturity of forage sorghums. Additionally, in vitro dry matter digestibility was reduced ($P<.05$) throughout maturity. These researchers also found that ADF, cellulose and lignin content of the ensiled materials was higher ($P<.01$) than those of the fresh forage due to a lower ($P<.01$) soluble carbohydrates, estimated digestible energy and estimated total digestible nutrients. Data of Burns (1968) showed that grain-type sorghums used for forage purposes progressively declined in their cellulose and ADF content as maturity advanced from the vegetative to the early dough stage. Burns (1968) reported that accumulation of soluble carbohydrates was the reason for these changes. Dry matter, lignin, and silica contents of sorghums increased through maturity in both parent and ratoon harvests, but their composition was similar for both harvests, (Aii, 1975).

Holt et al. (1963) found that yield, quality, and physical characteristics of sorghum forage were influenced by the stage of maturity of the plants at the time of harvest. At the first harvest or parent harvest, dry matter yield increased from the boot to the hard-dough stages. However, at the second harvest or ratoon harvest, dry matter yield decreased from the boot to the hard-dough stages. Plants harvested at early bloom stages produced much larger dry matter (DM) yields than those cut at vegetative stages of growth (Fribourg et al., 1976). Owen (1962) reported increases in Atlas DM production of 33% from the milk to the mature seed stages, and a 57% increase by delaying harvest an additional 10 d. Increases in the whole plant dry matter yield per ha, as plant maturity advanced, were found by Schake et al. (1982) which correspond to previous reports of Eilrich et al. (1964), Dotzenko et al. (1965), and Black et al. (1980).

Ensiling Losses and Seepage

Seepage losses are most obvious when ensiling material of low DM content (Vetter and Kendall, 1978). McDonald et al. (1968), ensiling fresh (15.9% DM) and wilted (30.3% DM) Italian Ryegrass, found that seepage from the silo containing the fresh grass had 4.8, 6.4 and 9.3% more water-soluble carbohydrates, DM and total nitrogen, respectively, than the wilted grass silage. The amount of seepage loss depends upon the crop species, crop maturity, and type and height of the storage structure. Gordon (1967) pointed out that seepage losses were practically eliminated when DM content of the silage was 30 to 35% or greater. Dry matter losses of 11.8 and 7.5% were reported by McDonald et al. (1968) for fresh (15.9% DM) and wilted (30.3% DM) Italian Ryegrass silages, respectively. These data are similar to those of Catchpoole's (1962) indicating decreased ensiling losses from early maturity through the dough stage. Schake et al. (1982) reported that mean DM ensiling losses were influenced by sorghum variety ($P<.05$) and stage of maturity ($P<.001$) for leaf, head and stem. Sweet forage sorghums were ensiled with only 3.8% DM losses during fermentation (Garrett and Worker, 1965). Although this report agrees closely with the 4% losses reported by Catchpoole (1962), they are much lower than the 23% ensiling losses of sweet sorghum obtained by Ramsey et al. (1961).

Storage losses of sorghum grain silage, due to fermentation and seepage, averaged 10.5, 7.2 and 4.0% of DM for milk to early dough, soft to hard dough, and hard seed stages of maturity, respectively (Browning and Lusk, 1967). Dry matter losses of up to 25% for Tracy sorghum silage have been reported by Browning et al. (1960).

Digestibility

Despite the great diversity of the sorghum genus, sorghum silages have been known to have lower feeding value than that of corn. Most feeding trials comparing the feeding value of sorghum silage to corn silages have strongly suggested a lower feeding value of the former as indicated by lowered cattle performance in the trials of Fitch and Wolberg (1934), Owen (1967), Cummins and McCullough (1969), McCone (1969) Denham (1971), and Newland et al. (1973). However, McCullough and Cummins (1974) reported similar protein digestibility of corn and FS-24 and FS-26 forage type sorghum silages. Danley and Vetter (1973) reported lower ($P<.01$) total digestible nutrients, estimated digestible energy ($P<.05$) and in vitro DM digestibility ($P<.05$) but no significant differences in crude protein digestibility when sorghum silage was compared to corn silage. Previous research of McCullough et al. (1964) indicated higher digestibility and greater dry matter intake of cattle fed medium height forage-type sorghums compared to either short grain-types or tall, high yielding sweet sorghums.

Kuhlman and Owen (1962) observed higher digestibility in varieties of sorghum with higher grain content than with forage varieties. Higher daily milk production was reported by Browning et al. (1961) on high grain-to-stalk ratio sorghum silages than for those of lower grain-to-stalk ratios when fed to lactating dairy cows.

With advancing maturity, DM digestibility of sorghum with high grain content tends to increase while DM digestibility of forage sorghums tends to decrease (Owen, 1967). Kuhlman and Owen (1962) pointed out that a high grain sorghum was equally digested at the milk stage and more digestible at the medium and hard dough stages than Atlas sorghum silage whose DM digestibility decreased from 61 to 52% as maturity advanced. However, DM digestibility of Atlas was depressed (50 to 46%) from the flower to the ripe seed stage whereas in a second trial, DM digestibility increased with advancing maturity (52 to 56%). Hibberd et al. (1981) reported that in vitro DM disappearance of a waxy grain sorghum remained unaffected through maturity, but relative digestibility of a bird-resistant grain sorghum continued to increase as maturity approached, possibly due to a reduction of tannins.

Schmid et al. (1975), working with grain and sweet sorghums, found a high correlation (r=.91) between in vitro and in vivo DM digestibility which suggests that in vitro techniques may satisfactorily be used to screen sorghums for in vivo digestibility.

<u>Ratooning</u>

The sorghum plants' ability to ratoon after cutting in the tropics and subtropics adds to its economic potential. Due to the special climatic conditions of those areas, it is possible to obtain several ratoon harvests from one planting. The basic unit of growth of grasses, the phytomer or individual tiller, is the most important factor in crops that may be harvested several times from one planting. Production and development of healthy tillers from the stubble of the parent harvest determines the success of the ratoon harvest. The limited information that exists regarding the feeding value of ratoon sorghum silages indicates potential. Escalada and Plucknett (1977) obtained marked increases in grain and stover yields of ratooned grain sorghums as rate of nitrogen fertilizer increased. Holt et al. (1963) pointed out that DM yield of Tracy sorghum was 22 t/ha when two harvests were collected. Higher yields per hectare per year have been reported in grain and forage sorghums by ratooning them in India, Hawaii, Australia, Arizona, California, and Philippines (Plucknett et al., 1970). Gorbet (1982) reported a grain yield of 50% or more of the first harvest yield when the ratoon harvest of selected grain sorghum hybrids was obtained. Plucknett et al. (1971) harvested forage sorghum in Hawaii at the dough stage of maturity and obtained up to six ratoon harvests with a total DM yield of 48,750 kg/ha in a 600-d period of growth.

Myer et al. (1982) reported that the ratoon grain harvest was equal to the parent harvest in feeding value for growing-finishing swine. Fernandez et al. (1982) obtained higher digestibility values from the ratoon sorghum grain silages than from the parent harvest when fed to lactating dairy cows.

The new high energy sorghum hybrids have not been investigated for ensiling or nutritional characteristics. The present experiment was designed to investigate three different types of sorghum silages (sweet, high grain and high energy) for DM yield, chemical composition, in vitro DM digestibility, and in vivo DM digestibility for both parent and ratoon harvests.

MATERIALS AND METHODS

Exp. 1

Plant material. Two high grain sorghum hybrids: ATx623 x RTx430 and ATx623 x 74CS5388; two high energy sorghum hybrids: ATx623 x Rio and ATx623 x Wray; and two sweet sorghum varieties: Rio and Wray were used in this experiment.

They were cultured at the Texas A&M University Farm west of College Station from March to November, 1983 and harvested at 50% anthesis, soft dough and hard dough stages of maturity.

Experimental design. A randomized split-split-plot design with three replicates was used to analyze fresh and ensiled sorghums (Steel and Torrie, 1980). Analysis of variance and Duncan's Multiple Range Test (1955) were performed with the Statistical Analysis System software package (SAS, 1982) to compare differences among means by sorghum type and stage of maturity, upon parent and ratoon harvests. Sorghum types represented the main plots, and maturity stages and harvests represented the sub-plots. Duncan's Multiple Range Test (1955) also conducted to establish chronological differences between parent and ratoon harvest means.

Cultural practices. Each individual plot consisted of three rows 6.7 m in length and 1.1 m between rows. Guard rows were planted to minimize border effects. The parent harvest was fertilized before planting with 168-90-90 kg/ha of N,P and K, respectively. Thirty days post-planting, 312 kg/ha of nitrogen were applied. Water was applied as needed during the growing season and again immediately after harvesting the plots to insure that enough moisture was available for regrowth. Both mechanical and chemical means were used to control weeds. Insecticide sprays were applied as needed on both harvests. Plots were thinned by hand 5 to 6 wk after planting to insure a final population of 193,000 plants per ha.

Harvesting technique. The whole plant at the three stages of maturity was harvested by hand, after randomly selecting a row within each plot. The plants were cut at 6 cm above ground level and weighed. A conventional silage field chopper was used to chop whole plants at a 2 cm theoretical cut. The row that was harvested at the soft dough stage was top-dressed with 90 kg/ha of nitrogen and allowed to grow for ratooning. The 50% anthesis harvest was accomplished when half of row's plant population started to flower. The same procedure was followed for the ratoon harvest. The soft dough and hard dough stage harvests were performed 20 and 45 d, respectively, following the 50% anthesis harvest. The hard dough stage of maturity was not accomplished at the ratoon harvest.

Ensiling Process. After cutting, the green chopped material was composited and divided in two portions: 1) 500 g of material were immediately stored at 4 C for later analyses, and 2) 3 kg of similar material were placed in a PVC air-tight laboratory silo. Silos were 60 cm in height and 10.2 cm in diameter. A thermocouple was installed in each silo to determine internal silage temperatures. Temperature was recorded daily for the first 5 d and thereafter every other day to d 30. Seepage was recovered on days 3, 6, 15 and 30 post-ensiling through a drain installed at the botton of the silos.

Sample preparation. Fresh harvested and 30 d ensiled sorghums were dried in a freeze drier and ground in a Wiley mill using a 1 mm screen. Thereafter, the samples were placed in wheaton jars, left open for 3 d to air to equilibrate and stored for chemical analyses. Air equilibrated samples were oven-dried at 105 C for 24 h to adjust for bound moisture content.

Dry matter yield. Within each plot, at each stage of maturity, a random sample of whole plant (1 m per row) was harvested, weighed and recorded. This value was then multiplied by the total number of m/ha and by the dry matter content of the sample to determine dry matter yield per ha (Suarez, 1976).

Ensiling loss. The silos were weighed 3 times; before ensilage, after been filled with the cut fresh whole plant sorghum and after 30 d to determine both initial and final material weights. These values were multiplied by their respective dry matter percentages and subtracted from each other to calculate dry matter loss. Seepage was measured and recorded on d 3, 6, 15 and 30 to determine seepage loss.

Chemical analyses. Air equilibrated, ground fresh and ensiled samples were used for determination of in vitro dry matter digestibility (IVDMD), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and acid insoluble ash (Ash) following the procedures by Goering and Van Soest (1970). However, NDF determination was modified using the procedure outlined by Robertson and Van Soest (1977) to eliminate residual starch. Also, VFA's, lactic acid and ethanol were determined via high pressure liquid chromatography.

In vitro dry matter digestibility. The procedure of Goering and Van Soest (1970) followed with the NDF modified procedure of Robertson and Van Soest (1977) was used to determine the in vitro dry matter digestibility (IVDMD). Duplicated samples of one-half g each were weighed into 35 x 250 mm pyrex culture tubes and placed into racks of 108 capacity. Fourty-two ml of the medium-reducing solution were added to each tube and allowed to soak for 1 h. Ten ml of inoculum (collected and filtered rumen fluid) per tube were also added. After flushed with CO2 and covered with a stopper with a Bunsen valve, the tubes were constantly shaken and incubated at 39 C for 48 h. Incubation was stopped by the addition of 1 ml of 5% w/v mercuric chloride and refrigirated until analyzed for NDF.

Before the contents of the incubation tubes were transfered to 600 ml Berzelius beakers with the aid of 50 ml of neutral detergent solution (NDS) and a rubber policeman, the tubes were vortex to allow complete transference of their contents. After refluxed for 30 min and allowed to cool, an additional 50 ml of NDS and 2 ml of amylase solution were added to the samples and again refluxed for 1 h. The materials were filtered on previously tared filter crucibles (50 ml) of coarse porosity and washed twice with hot water (90 C) and twice with reagent grade acetone. The crucibles were oven-dried at 105 C overnight, allowed to cool in a dessicator and weighed. Samples were ashed at 525 C for 8 h, allowed to cool and reweighed.

Standard samples were processed to adjust IVDMD due to microbial and organic matter content of the inoculant. The in vitro dry matter digestibility of the samples was calculated as:

$$\text{IVDMD} = \frac{\text{Dry wt of sample} - \text{Undigested NDF}}{\text{Dry wt of sample}} \times 100$$

Undigested NDF = (Filtered wt of sample - Wt of standard) - Ashed wt.

Neutral detergent fiber. The procedure utilized was a rapid method to determine the insoluble cell wall constituents. One g of each sample was weighed, placed into a 600 ml Berzelius beaker and refluxed with 50 ml of NDS for 30 min. The samples were allowed to cool and an additional 50 ml of NDF and 2 ml of amylase solution were added. After refluxed for 1 h, the solution was filtered on already tared crucibles of coarse porosity and washed twice with hot water and twice with reagent grade acetone. The crucibles were dried for 8 h at 105 C, cooled and weighed. The NDF of the samples was calculated as:

$$\text{NDF} = \frac{\text{Wt of residue} - \text{Wt of crucible}}{\text{Wt of sample}} \times 100$$

Acid detergent fiber. This procedure provides a rapid method of lignocellulose determination. Weighed 1 g samples were transfered to 600 ml Berzelius beakers containing 100 ml of acid detergent solution. After refluxed for 1 h, the solution was filtered, rinsed and handled as described above. However, hexane was added to the crucible while it still contained acetone. The crucibles were dried overnight, cooled and weighed. The ADF of the samples was calculated as:

$$ADF = \frac{\text{Wt of residue} - \text{Wt of crucible}}{\text{Wt of sample}} \times 100$$

Acid detergent lignin. The acid detergent fiber procedure was used as a preparatory step. The crucibles containing the acid residue were placed on a glass tray, covered with 30 ml of cooled 72% sulfuric acid solution and allowed to stand for 3 h. They were stirred occasionally with a glass rod during that period to break any lumps. The crucibles were refilled 2 to 3 times to provide complete saturation. After washing with hot water until free from acid, the crucibles were dried overnight at 105 C and weighed. Then, they were ashed at 525 C for 8 h, cooled and reweighed. The lignin content of the samples was calculated as:

$$\text{Lignin} = \frac{\text{Wt of residue} - \text{Wt of ashed crucible}}{\text{Wt of sample}} \times 100$$

Acid insoluble ash. The acid insoluble ash fraction was calculated as:

$$\text{Ash} = \frac{\text{Wt of ashed crucible} - \text{Wt of crucible}}{\text{Wt of sample}} \times 100$$

High pressure liquid chromatography. Ethanol, lactic acid and VFA's (acetic, propionic and butyric) were identified and quantified via high pressure liquid chromatography (HPLC). Five g of frozen silage and 15 g of distilled water were weighed, placed into a 100 ml wheaton jar and refrigerated for 24 h to allow equilibration. The sample was filtered through a 10 mm millipore prefilter and a 0.45 micron millipore filter with a 5 ml glass syringe and Swinney adapter, placed into 8-ml screw cap vials and refrigerated until analyzed by HPLC.

The separation, identification and quantification of the ethanol, lactate and VFA's was accomplished in an HPLC system equipped with an Altex 156 refractive index detector, set at 1 range, which was connected to an Apple IIe computer through an Adalab interface card. A Beckman 110 A solvent pump connected to a Reodyne 7125 injection valve with a 10 ul loop served as the propulsor of samples. An Aminex HPX-87H column separated organic compounds by ion exclusion and partition chromatography. Solvent pump was set at 1000 PSI with a flow rate of 0.8 ml/m. Column temperature was maintained at 65 C. Injected sample size was 50 ul. Mobil phase was 0.01 N H2SO4 on HPLC water. Chromatochart, a software program, accomplished the task of integration.

Integrated peaks were compared to pure standards containing known amounts of ethanol, lactate and VFA's to identify and quantify individual acids and ethanol. Duplicate subsamples were analyzed to minimize error sampling, and results were adjusted for dilution factors to determine correct concentration.

Exp. 2

Plant material. A high grain sorghum hybrid, ATx623 x RTx430; a high energy sorghum hybrid, ATx623 x Rio; and a sweet sorghum variety, Wray, were used in this experiment. Both parent and ratoon harvests were harvested at the hard dough stage of maturity. The sweet sorghum variety did not ratoon adequately to produce a ratoon harvest, therefore that treatment was eliminated.

Experimental design. A simple change-over design, with six steers, two different animals per treatment per period, was used to analyze in vivo digestibility of nutrients in the three sorghum silages at both harvests (Federer, 1955). Analysis of variance and Duncan's Multiple Range Test (1955) were conducted to evaluate differences among treatment means.

Cultural practices. Cultural practices were identical to those in Exp. 1 except that .407 ha of each sorghum hybrid or variety was planted; two blank rows were left between plots and these plots were not thinned.

Harvesting technique. The same conventional silage field chopper used in Exp. 1 was used to harvest the whole plant at the hard dough stage of maturity. The plant was chopped at a 2 cm theoretical cut. After the parent cutting, the stubble was top-dressed with 90 kg/ha of nitrogen and irrigated as needed.

<u>Ensiling process.</u> After cutting, the chopped material was placed in one of these silos 1.32 m in height and 2.50 m in diameter. These silos were lined with a plastic silopress bag and secured to limit exposure to air. Thermometers were installed in each silo and temperature was recorded daily for the first 5 d and thereafter every other day until d 29. The ratoon harvest was harvested using the same procedure outlined for the parent harvest. However, the chopped material was preserved in plastic bags placed in 208-liter barrels lined with plastic bags to exclude air from silage. Silage temperature was not recorded.

<u>Digestion trial.</u> A digestion trial (80 d) was conducted with six steers fed individually, two for each sorghum silage. In vivo DM and ADF digestibilities were obtained using Chromic oxide as an external marker which was mixed with the supplement at 0.25% of DM of the ration and fed 10 d prior to the 6 d collection period (table 1). Each pair of calves was rotated through this procedure with each calf fed each diet three times. Daily intake was adjusted to the level obtained during the 8 d adaptation period. Steers were fed at only 85% of the adaptation period intake to insure total feed consumption. Rectal fecal grab samples were collected twice daily on a staggered schedule to include diurnal digestion variation. Feed samples were taken 2 d before the beginning until 2 d before concluding the sampling period (table 2). Fecal and feed samples were immediately

frozen after collection.

Fecal samples were composited on a per animal per period basis before drying for 48 h at 55 C followed by grinding through a Wiley mill to pass a 1 mm screen. Feed samples were also composited in the same way as fecal samples, except they were dried in a freeze dryer. Thereafter, the samples were placed in wheaton jars, left open for 3 d for air equilibration and stored for chemical analyses. The samples were then dried at 105 C for 24 h to adjust for bound moisture content.

Air equilibrated ground fecal and feed samples were analyzed for Chromic oxide using procedures outlined by Kimura and Miller (1956). Acid detergent fiber was determined by methods of Goering and Van Soest (1970) as a preparatory step in the in vivo ADF digestibility. Dry matter content of feed was used to calculate dry matter intake.

Chromic oxide determination. The colorimetric procedure used nitric-perchloric acid oxidation with a molybdate catalyst. According to Kimura and Miller (1956), one g of air equilibrated feed sample was weighed and placed into a tecator digestion tube with 3 boiling beads. One ml of a 0.5% NMoO4 solution and 10 ml of concentrated HNO3 were added to the tubes. They were placed in 40-tube digestion racks and allowed to stand overnight in a hood.

TABLE 1. IN VIVO DIGESTIBILITY TRIAL SCHEDULE

Date (1983 to 1984)					
From			To		Activity
			Parent harvest		
October,	23	to	October,	30	- Adaptation period 1
October,	31	to	November,	05	- Feed samples for period 1
November,	02	to	November,	07	- Fecal samples for period 1
November,	08	to	November,	15	- Adaptation period 2
November,	16	to	November,	21	- Feed samples for period 2
November,	18	to	November,	23	- Fecal samples for period 2
November,	24	to	December,	01	- Adaptation period 3
December,	02	to	December,	07	- Feed samples for period 3
December,	04	to	December,	09	- Fecal samples for period 3
			Ratoon harvest		
December,	10	to	December,	17	- Adaptation period 4
December,	18	to	December,	23	- Feed samples for period 4
December,	20	to	December,	25	- Fecal samples for period 4
December,	26	to	January,	02	- Adaptation period 5
January,	03	to	January,	08	- Feed samples for period 5
January,	05	to	January,	10	- Fecal samples for period 5

TABLE 2. DIET WITH CHROMIC OXIDE ADDED

Ingredient	%
Sorghum silage	86
Cottonseed meal	10
Vitamin/mineral premix	3.75
Chromic oxide[a]	0.25
Total ration	100.00

[a] Chromic oxide was mixed in the premix in batches of 20 kg, of which the vitamin/mineral premix represented 18.75 gm and Chromic oxide represented 1.25 gm.

Glass vials, filled to about half capacity with distilled water, were placed in the top of the digestion tubes. The samples were digested in a programed digestion block (table 3). At slide 3, 7 ml of perchloric acid was added to the tubes after they were cooled. When digestion was completed, the tubes were brought to volume with distilled water, filtered through 41-9.0 cm Whatman paper filters to remove silica and read in a Spectronic colorimeter set at 430 mu.

A regression curve was determined digesting a pure chromic oxide sample and comparing it to standards made from purified potassium dichromate. Chromium concentration was determined as:

$$CR_2O_3 = \frac{\text{Absorbance} - 0.0004426}{\text{Wt of sample} \times 0.0045291}$$

Fecal samples were analyzed similarly to feed samples.

Acid detergent fiber. Acid detergent fiber (ADF) was calculated as in Exp.1. for both feed and fecal samples.

In vivo true digestibility. With the results of the Chromium, dry matter and ADF assays, true DM and ADF digestibilities (TDMD and TADFD) were calculated as:

$$TDMD = 100 \times \left(1 - \frac{\%\ CR2O3\ Feed}{\%\ CR2O3\ Fecal} \right)$$

$$TADFD = 100 \times \left(1 - \left(\frac{\%\ CR2O3\ Feed}{\%\ CR2O3\ Fecal} \times \frac{\%\ ADF\ Fecal}{\%\ ADF\ Feed} \right)\right)$$

TABLE 3. DIGESTION BLOCK SEQUENCE

Slide	Time, h	Temperature, C	
1	1:00	75	
2	2:00	150	
3	2:35	150	* cool and add acid
4	5:05	235	

The same procedure was followed to evaluate the ratoon harvest.

Epx. 3

The same sorghum hybrids and variety cultured during the summer and fall of 1983 at the Texas A&M University Farm for the in vivo digestibility trial were used in this experiment.

The purpose of this trial was to evaluate the influence of Silamix, a commercial product of Ralco-Mix Products, Inc., upon fermentation of whole plant sorghum silages and its effect on seepage losses and in vitro dry matter digestibility.

A randomized split-plot design, with harvest and sorghum types serving as main plots, and treatments serving as subplots, was used as in Exp. 1. Analysis of the variance and Duncan's Multiple Range Test (1955) were also performed as in Exp. 1. Cultural practices and harvesting techniques were the same as in Exp. 2.

The green chopped material was handled as in Exp. 1 except that Silamix was added to 3 kg of chopped fresh sorghum at the level of .05% of silage weight.

The samples were prepared and seepage collected as in Exp. 1. Dry matter recovery was determined by calculating the initial and final material weights as in Exp. 1, multiplying them by their dry matter content and substracting the final DM wt from the initial DM wt. Frozen samples were used to determine pH.

Both fresh and ensiled sorghum samples were analyzed for in vitro dry matter digestibility (IVDMD) following techniques outlined in Exp 1. Volatile fatty acids (acetic, propionic and butyric), were determined following the procedure outlined by Byers (1980). They were identified and analyzed via gas liquid chromatography (GLC). Five g of frozen material and 15 g distilled water were weighed, placed into wheaton jars and refrigerated for 24 h to allow equilibration. The sample was filtered through # 40 Whatman filter papers. Four ml of filtrate and 1 ml of 25 % metaphosphoric acid were placed in a centrifuge tube and centrifuged for 10 min at 12,000 X g. The supernatant was decanted to a screw cap vial and frozen. One ml of supernatant and 0.1 ml of internal standard solution (2 ethyl butyric) were placed into a small test tube, vortex for 15 s and filtered through a 0.45 micron millipore filter with a disposable syringe and # SX0002500 millipore filter holder.

One microliter of the filtrate was injected into a Varian Aerograph Series 2100 gas-liquid chomatograph system equipped with a 183 x 4 mm ID glass. Column packing was 15% SP 1220 coated on 100/120 mesh chromosorb with 1% phosphoric acid. The oven temperature was set at 135 C and the inlet detector at 150 C. The carrier gas was nitrogen at a flow rate of 20 ml/min. A Hewlett Packard 3390A integrator was connected to the GLC to accomplish the task of integration.

The readouts of the GLC were compared to known standards to identify and quantify individual acids in both fresh and ensiled materials. Duplicate subsamples were analyzed to minimize error of sampling, and the results were adjusted for dilution factors to determine correct concentration.

RESULTS AND DISCUSSION

Exp. 1

Dry matter content and yield. Numerous scientists (Owen, 1962; Holt et al., 1963; Owen, 1967; Aii, 1975; Fribourg et al., 1976; Suarez, 1976; Black et al., 1980; Schake et al., 1982) have repeatedly documented that dry matter (DM) content and yield of the sorghum plant increased with advancing maturity. Data from the current experiment support this observation with dry matter content being influenced ($P<.01$) by type of sorghum and maturity for both fresh and ensiled sorghums (tables 4, 5, 6 and 7), with dry matter yield also influenced ($P<.01$) by sorghum type and maturity (tables 4 and 5) with numerous interactions indicated (table 1A). However, both DM content and yield decreased ($P<.01$) from parent to ratoon harvest. Mean DM content of fresh sorghums was 24.6, 32.7 and 40.1% for the 50% anthesis (A), soft dough (SD) and hard dough (HD) maturities, and 24.0, 31.5 and 37.8% for A, SD and HD maturities for sorghum silages, respectively. Mean DM yield followed the same trend with 6523, 9990 and 16267 kg/ha for A, SD and HD maturities for fresh sorghums. The DM content decreased ($P<.01$) from 31.0 to 30.6% and 30.1 to 29.1% from parent to ratoon harvest for fresh and ensiled sorghums, respectively, while DM yield declined ($P<.01$) from 12056 to 6377 kg/ha for fresh sorghums.

In general, DM content differed ($P<.01$) among the sorghum

TABLE 4. FRESH SORGHUM DRY MATTER, YIELD, CHEMICAL COMPOSITION AND IN VITRO DRY MATTER DIGESTIBILITY BY SORGHUM TYPE

	Type						
Variable	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388	MSE
Dry matter, %	32.6^{d}	29.0^{ef}	30.8^{de}	27.9^{f}	32.6^{d}	32.3^{d}	5.09
Dry matter yield, kg/ha	11007^{e}	14218^{d}	9298^{f}	10032^{ef}	7077^{g}	6787^{g}	3631427
	Chemical composition, %						
Neutral detergent fiber	51.5	49.9	51.7	53.1	51.0	52.7	6.85
Acid detergent fiber	31.4	30.7	31.9	33.1	31.0	31.8	2.37
Acid detergent lignin	4.1^{efg}	4.2^{ef}	4.8^{d}	4.5^{de}	3.7^{g}	3.9^{fg}	.21
Ash	2.4^{g}	2.6^{fg}	2.7^{fg}	2.9^{ef}	3.3^{d}	3.2^{de}	.21
	In vitro digestibility, %						
Dry matter	75.0^{a}	74.9^{a}	73.0^{b}	72.0^{b}	74.6^{a}	73.4^{ab}	3.28

^{a,b,c} Means in same row with different superscripts differ ($P<.05$).

^{d,e,f,g} Means in same row with different superscripts differ ($P<.01$).

TABLE 5. FRESH SORGHUM DRY MATTER, YIELD, CHEMICAL COMPOSITION AND IN VITRO DRY MATTER DIGESTIBILITY BY MATURITY AND HARVEST

Variable	Maturity: Anthesis, 50%	Maturity: Soft dough	Maturity: Hard dough	MSE	Harvest: Parent	Harvest: Ratoon	MSE
Dry matter, %	24.6[e]	32.7[d]	40.1[c]	2.47	31.0[c]	30.6[d]	2.07
Dry matter yield, kg/ha	6523[e]	9990[d]	16267[c]	4860322	12056[c]	6377[d]	2715710
Chemical composition, %							
Neutral detergent fiber	57.6[c]	49.4[d]	44.6[e]	4.88	49.5[d]	54.8[c]	6.83
Acid detergent fiber	34.9[c]	30.0[d]	28.7[e]	2.04	31.8[c]	31.4[d]	2.38
Acid detergent lignin	3.8[e]	4.3[d]	4.9[c]	.23	4.3	4.1	.31
Ash	2.6[e]	2.9[d]	3.2[c]	.25	2.8[b]	2.9[a]	.26
In vitro digestibility, %							
Dry matter	72.9[d]	73.9[d]	75.5[c]	3.17	74.1	73.4	4.40

[a,b] Means within maturity or harvest in same row with different superscripts differ ($P<.05$).

[c,d,e] Means within maturity or harvest in same row with different superscripts differ ($P<.01$).

TABLE 6. SORGHUM SILAGE DRY MATTER, ENSILING CHARACTERISTICS, CHEMICAL COMPOSITION AND IN VITRO DRY MATTER DIGESTIBILITY BY SORGHUM TYPE

	Type						
Variable	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388	MSE
Dry matter, %	30.2[e]	27.0[f]	30.1[e]	27.9[f]	31.6[d]	31.4[d]	1.54
Ensiling characteristics							
Dry matter ensiling loss, %	11.2[ab]	14.1[a]	6.3[bc]	5.8[c]	5.7[c]	5.4[c]	37.07
Seepage, ml/30d	82.2[f]	180.3[d]	125.5[e]	171.7[d]	56.7[f]	52.5[f]	1443.81
Temperature, C	24.9[f]	24.7[f]	27.1[e]	26.9[e]	27.7[d]	27.3[de]	7.02
Chemical composition, %							
Neutral detergent fiber	56.8[d]	56.6[d]	54.6[e]	55.0[e]	52.1[f]	52.3[f]	3.17
Acid detergent fiber	34.3[ef]	35.4[d]	33.5[f]	34.5[de]	31.8[g]	32.3[g]	1.31
Acid detergent lignin	3.96[ef]	4.08[ef]	4.06[ef]	4.54[d]	3.86[f]	4.11[e]	.06
Ash	3.1	3.4	2.9	3.3	3.6	3.5	.37
In vitro digestibility, %							
Dry matter	72.0[e]	71.1[f]	69.6[g]	69.4[g]	73.0[d]	72.5[de]	.90

[a,b,c] Means in same row with different superscripts differ ($P<.05$).

[d,e,f,g] Means in same row with different superscripts differ ($P<.01$).

TABLE 7. SORGHUM SILAGE DRY MATTER, ENSILING CHARACTERISTICS, CHEMICAL COMPOSITION AND IN VITRO DRY MATTER DIGESTIBILITY BY MATURITY AND HARVEST

	Maturity				Harvest		
Variable	Anthesis, 50%	Soft dough	Hard dough	MSE	Parent	Ratoon	MSE
Dry matter, %	24.0[e]	31.5[d]	37.8[c]	3.41	30.1[c]	29.1[d]	1.49
Ensiling characteristics							
Dry matter ensiling loss, %	9.5[a]	7.1[b]	7.5[b]	26.12	8.7[a]	7.3[b]	17.43
Seepage, ml/30d	214.3[c]	58.8[d]	6.3[e]	814.33	161.1[c]	36.0[d]	2370.31
Temperature, C	26.6[d]	24.8[e]	29.4[c]	4.16	28.7[c]	23.1[d]	11.66
Chemical composition, %							
Neutral detergent fiber	61.8[c]	51.4[d]	46.2[e]	5.43	52.5	57.7	8.4
Acid detergent fiber	38.3[c]	31.3[d]	28.7[e]	2.79	32.0[d]	36.0[c]	4.41
Acid detergent lignin	4.2	4.0	4.1	.56	4.2[a]	3.9[b]	.53
Ash	3.1[d]	3.2[d]	3.9[c]	.65	3.1[d]	3.6[c]	.38
In vitro digestibility, %							
Dry matter	69.8[e]	72.0[d]	72.9[c]	2.47	71.4	71.0	4.1

[a,b] Means within maturity or harvest in same row with different superscripts differ (P<.05).

[c,d,e] Means within maturity or harvest in same row with different superscripts differ (P<.01).

types within SD and HD maturities at both parent and ratoon harvests for both fresh and ensiled sorghums while within A maturity differences occurred for fresh ($P<.05$) and ensiled ($P<.01$) sorghums at the ratoon harvest, but not for the parent harvest (tables 8 and 9). This is the basis of the type x maturity interaction ($P<.01$) for both sorghum states. The DM yield of fresh sorghum was different ($P<.01$) among sorghum types within A maturity of both harvests and at SD maturity of the parent harvest, whereas differences were less ($P<.05$) within SD maturity of the ratoon harvest, with no differences observed within HD maturity of the parent harvest (table 10). The sweet sorghums had higher ($P<.05$) DM yield at each maturity except for HD maturity ($P>.05$) at both harvests compared to other sorghums.

At ratoon harvest, DM content of Wray at A maturity, and ATx623xRTx430 and ATx623xRio at SD maturity decreased ($P<.05$) during ensiling (tables 2A, 3A, and 4A). At parent harvest, no significant change occurred in DM content of any type of sorghum during ensiling at any maturity. In general, mean DM content was higher and DM yield lower for ratoon than parent harvest which explains the maturity x harvest interaction ($P<.01$) of both DM content and yield.

Holt et al. (1963) reported higher DM content, but lower DM yield of sorghum silage for the ratoon harvest at early stages of maturity than the parent harvest. However, Aii (1975) reported that DM yield of sorghum increased with advancing maturity in both parent and ratoon harvests.

TABLE 8. DRY MATTER OF FRESH SORGHUMS FOR BOTH HARVESTS BY SORGHUM TYPE AND MATURITY (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	23.9^{f}	$34.5^{e,w}$	$38.7^{d,yz}$	.26	$30.0^{c,u}$	$36.0^{b,w}$	1.14
Wray	21.8^{c}	$27.8^{bc,y}$	$33.7^{b,z}$	4.77	27.3^{v}	32.1^{y}	2.65
ATx623x Rio	21.2^{f}	$30.5^{e,x}$	$41.4^{d,xy}$	1.73	$26.6^{c,v}$	$34.2^{b,x}$	1.11
ATx623x Wray	20.4^{f}	$27.9^{e,y}$	$34.9^{d,z}$	2.35	$24.6^{c,v}$	$34.0^{b,x}$	2.87
ATx623x RTx430	22.8^{f}	$33.4^{e,w}$	$45.0^{d,wx}$	1.51	$27.4^{c,uv}$	$34.1^{b,x}$	2.89
ATx623x 74CS5388	22.1^{f}	$34.8^{e,w}$	$47.3^{d,w}$	3.05	27.3^{v}	33.9^{x}	.53

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ (P<.05).

[d,e,f] Means within harvest in same row with different superscripts differ (P<.01).

[u,v] Means in same column with different superscripts differ (P<.05).

[w,x,y,z] Means in same column with different superscripts differ (P<.01).

TABLE 9. DRY MATTER OF SORGHUM SILAGES FOR BOTH HARVESTS BY SORGHUM TYPE AND MATURITY (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	21.8[g]	31.2[f,wx]	35.7[e,x]	3.27	28.3[f,w]	33.9[e,w]	.13
Wray	21.3[g]	27.1[f,y]	29.6[e,y]	.43	24.5[f,z]	30.8[e,x]	.16
ATx623x Rio	22.8[g]	31.3[f,wx]	38.5[e,x]	1.60	25.4[c,xyz]	32.3[b,wx]	1.89
ATx623x Wray	21.8[g]	29.0[f,xy]	34.7[e,x]	1.57	24.8[f,yz]	31.6[e,x]	.32
ATx623x RTx430	22.7[g]	32.4[f,w]	44.7[e,w]	3.00	26.3[f,xy]	31.7[e,x]	.02
ATx623x 74CS5388	21.6[d]	33.7[c,w]	45.1[b,w]	14.12	26.7[wx]	33.6[w]	.98

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c,d] Means within harvest in same row with different superscripts differ (P<.05).

[e,f,g] Means within harvest in same row with different superscripts differ (P<.01).

[w,x,y,z] Means in same column with different superscripts differ (P<.01).

TABLE 10. DRY MATTER YIELD FOR BOTH HARVESTS BY SORGHUM TYPE, MATURITY AND HARVEST (kg/ha)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	$9281^{e,k,vw}$	$13776^{e,k,w}$	19819^{d}	4607859	$5695^{l,w}$	$6463^{l,tu}$	552343
Wray	10743^{v}	17752^{v}	19510	17184158	10472^{v}	11456^{s}	5201877
ATx623x Rio	$7001^{f,xy}$	$12952^{e,w}$	15603^{d}	1245802	5387^{w}	5548^{tu}	1174544
ATx623x Wray	$7972^{f,k,wx}$	$12657^{e,w}$	17672^{d}	178531	$4616^{l,wx}$	9790^{st}	4410430
ATx623x RTx430	$5374^{f,xz}$	$9754^{e,m,x}$	12562^{d}	1399467	4016^{wx}	$3681^{n,u}$	166420
ATx623x 74CS5388	$4544^{c,z}$	$9973^{b,x}$	11225^{b}	2094863	3607^{x}	4114^{u}	552174

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ (P<.05).

[d,e,f] Means within harvest in same row with different superscripts differ (P<.01).

[k,l] Means between harvests in same row with different superscripts differ (P<.05).

[m,n] Means between harvests in same row with different superscripts differ (P<.01).

[s,t,u] Means in same column with different superscripts differ (P<.05).

[v,w,x,y,z] Means in same column with different superscripts differ (P<.01).

Fernandez et al. (1982) reported that DM yield of grain sorghum was 80% of initial harvest. Megehee (1975) found no significant change in DM content during ensiling of grain and intermediate type sorghum plants, while Rio silage declined ($P<.01$) 7 percentage units. In general, DM content and yield were constant with previously published data.

<u>Ensiling characteristics.</u> It is a well documented fact that dry matter ensiling losses (DMEL) and seepage are more common to material low in DM content (Catchpoole, 1962; Browning and Lusk, 1967; McDonald et al., 1968; Vetter and Kendall, 1978; Schake et al., 1982). The DMEL was influenced ($P<.05$) by sorghum type, maturity and harvest, with seepage and temperature of silage also influenced ($P<.01$) by the same variables (tables 6 and 7). The DMEL decreased ($P<.05$) from A to SD maturities, but slightly increased ($P>.05$) from SD to HD maturities. Seepage decreased ($P<.05$) steadily with advancing maturity (214.3, 58.8 and 6.3 ml from A, SD and HD maturities, respectively) while silage temperature decreased ($P<.01$) from A to SD maturities, but increased ($P<.01$) from SD to HD maturities (26.6, 24.8 and 29.4 C for A, SD and HD maturities, respectively). DMEL, seepage and temperature decreased ($P<.05$) from parent to ratoon harvest. However, no differences ($P>.05$) occurred in DMEL of any type of sorghum silage with advancing maturity for either harvest (table 11), except for Wray at the ratoon harvest ($P<.05$). Most types of sorghums did not change ($P>.05$) in DMEL as maturity advanced

TABLE 11. DRY MATTER ENSILING LOSS FOR BOTH HARVESTS BY SORGHUM TYPE, MATURITY AND HARVEST (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	19.9	12.2	9.9	55.77	6.9[z]	7.0	16.88
Wray	19.0	15.5[k]	14.9	43.86	17.4[b,y]	5.5[c,l]	10.64
ATx623x Rio	6.2	2.1	8.3	10.15	7.9[z]	7.0	10.66
ATx623x Wray	7.1	4.6	2.3	14.33	5.3[z]	8.6	30.54
ATx623x RTx430	7.5	6.1	1.4	14.86	5.0[z]	8.6	23.13
ATx623x 74CS5388	9.8	4.6	5.7	48.32	3.0[z]	2.0	.71

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ ($P<.05$).

[k,l] Means between harvests in same row with different superscripts differ ($P<.05$).

[y,z] Means in same column with different superscripts differ ($P<.05$).

TABLE 12. SEEPAGE LOSS FOR BOTH HARVESTS BY SORGHUM TYPE, MATURITY AND HARVEST

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
	ml/30d						
Rio	385.7^{e,m,w}	16.7^{f,z}	0^{f}	695.8	8.7^{n,wx}	0	112.7
Wray	618.0^{e,m,v}	203.0^{f,k,w}	33.0^{g}	252.1	281.0^{n,v}	0^{l}	3754.5
ATx623x Rio	409.7^{e,k,w}	141.7^{f,m,x}	0^{g}	630.4	76.0^{l,w}	0^{n}	1837.5
ATx623x Wray	453.3^{e,m,w}	254.3^{f,k,v}	5.0^{g}	1266.8	146.0^{b,n,v}	0^{c,l}	409.5
ATx623x RTx430	192.0^{b,k,x}	91.3^{c,k,y}	0^{d}	1572.9	0^{l,x}	0^{l}	0
ATx623x 74CS5388	215.7^{e,m,x}	46.7^{f,yz}	0^{f}	707.1	0^{n,x}	0	0

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c,d] Means within harvest in same row with different superscripts differ (P<.05).

[e,f,g] Means within harvest in same row with different superscripts differ (P<.01).

[k,l] Means between harvests in same row with different superscripts differ (P<.05).

[m,n] Means between harvests in same row with different superscripts differ (P<.01).

[v,w,x,y,z] Means in same column with different superscripts differ (P<.01).

at the parent harvest. Mean DMEL for Wray not only decreased ($P<.05$) from A to SD maturity at the ratoon harvest, but also from the parent to the ratoon harvest at SD maturity. Differences ($P<.05$) in DMEL among sorghum types within maturity only occurred for A maturity at the ratoon harvest with mean of Wray being the highest. The height of the experimental silos may have also influenced DMEL as reported by Gordon (1967).

Seepage loss for each type of sorghum silage decreased ($P<.05$) with advancing maturity at the parent harvest, with no loss at SD maturity for the ratoon harvest (table 12). The high grain hybrids had the least ($P<.01$) seepage among types of sorghum silage during ensiling at every stage of maturity for both harvests. Differences ($P<.05$) in seepage between harvests at A and SD at maturity stages were found for every type of sorghum silage. This explains the type x maturity, type x harvest and maturity x harvest interactions ($P<.01$) which occurred in seepage of sorghum silages used in this trial.

The mean temperature of sweet sorghum silages increased for Rio ($P<.05$) and Wray ($P<.01$) with advancing maturity at the parent harvest, while the opposite occurred at the ratoon harvest. However, temperature of ATx623xWray ($P<.05$), and ATx623xRTx430 and ATx623x74CS5388 ($P<.01$) decreased from A to SD maturities, and then increased from SD to HD maturities for the parent harvest (table 13). The temperature decreased ($P<.05$) for all sorghum types as

TABLE 13. TEMPERATURE OF SILAGE FOR BOTH HARVESTS BY SORGHUM TYPE, MATURITY AND HARVEST (C)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	27.9[c,k,y]	29.1[b,k,x]	29.3[b,y]	8.57	20.0[b,l,z]	18.2[c,l,z]	17.16
Wray	26.7[e,k,z]	29.4[d,k,x]	29.5[d,xy]	8.92	20.1[d,l,z]	17.9[e,l,z]	15.55
ATx623x Rio	28.9[k,x]	28.4[k,xy]	29.2[y]	8.75	26.6[d,l,y]	22.6[e,l,y]	5.60
ATx623x Wray	29.1[b,k,x]	27.7[c,k,yz]	29.0[b,y]	10.99	26.6[d,l,y]	22.1[e,l,y]	5.74
ATx623x RTx430	28.7[d,x]	27.2[e,k,z]	29.9[d,x]	10.40	27.9[d,x]	24.7[e,l,x]	1.94
ATx623x 74CS5388	28.9[e,k,x]	27.5[f,k,yz]	29.8[d,x]	3.16	27.5[d,l,xy]	22.9[e,l,y]	7.58

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ (P<.05).

[d,e,f] Means within harvest in same row with different superscripts differ (P<.01).

[k,l] Means between harvests in same row with different superscripts differ (P<.01).

[x,y,z] Means in same column with different superscripts differ (P<.01).

maturity advanced at the ratoon harvest. Differences (P<.01) among sorghum types within maturities were observed for both harvests. In general temperature was higher (P<.01) for parent than for ratoon harvest at every maturity stage of any type of sorghum silage which could be partially explained by enviromental temperature influencing internal temperature of the silage.

Sorghum DMEL of 25 and 23% have been reported by Browning et al. (1960) and Ramsey et al. (1961), respectively, which is considerably higher than observed in the current study, where there was DMEL without any seepage loss. However, Garrett and Worker (1965) and Catchpoole (1962) reported only 3.8 and 4% DMEL, respectively, for sweet sorghum silages. Gordon (1967) indicated that seepage loss was practically eliminated when DM content of the silage was 30 to 35% or greater. No reports were found in the literature regarding ensiling characteristics of ratoon on high energy sorghums.

Chemical composition. Structural carbohydrates of forage and grain-type sorghums often decrease with advancing maturity (Vinall et al., 1924; Webster and Davies, 1956; Burns, 1968; Suarez, 1976; Black et al., 1980). Data from the current experiment show similar trends with different interactions indicated (table 1A). While NDF and ADF of fresh sorghum were not influenced by sorghum type (P>.05), both maturity and harvest influenced (P<.01) NDF and ADF, decreasing (P<.01) with advancing maturity and from parent to ratoon harvest, except for NDF that increased (P<.01) from parent to ratoon harvest. Both NDF and ADF of sorghum silage differed ($P<.01$) among sorghum types, decreasing ($P<.01$) with advancing maturity and from parent to ratoon harvest except for ADF that increased ($P<.01$) from parent to ratoon harvest (tables 4, 5, 6 and 7). The ADL and ash of fresh sorghums were influenced ($P<.01$) by sorghum type, maturity and harvest except for ADL that did not change ($P>.05$) between harvests (tables 4 and 5), whereas ADL content of silage was influenced ($P<.01$) only by sorghum type and maturity. Ash content increased with advancing maturity ($P<.01$) and harvest ($P<.05$) as shown in tables 6 and 7.

The NDF and ADF of the high energy sorghums steadily decreased with advancing age at parent harvest ($P<.01$) for both fresh and ensiled states, and at ratoon harvest ($P<.05$) of fresh sorghum. However, only the NDF of ATx623xWray decreased ($P<.05$) with advancing maturity at the ratoon harvest of sorghum silage (tables 14, 15, 16 and 17). At both harvests, the NDF and ADF of Rio and Wray did not change ($P>.05$) as maturity advanced for fresh sorghum. For sorghum silage, both NDF and ADF of Rio and Wray decreased ($P<.01$) with advancing maturity at both harvests except for the parent ADF content of Wray that declined ($P<.05$) at a slightly lower rate. At the parent harvest, the NDF and ADF of fresh high grain types decreased ($P<.01$) from A to SD maturity with no changes ($P>.05$) from SD to HD maturity. A decrease in NDF of ATx623x74CS5388 occurred ($P<.01$) with advancing maturity at the ratoon harvest of fresh and ensiled

TABLE 14. NEUTRAL DETERGENT FIBER OF FRESH SORGHUMS FOR BOTH HARVESTS BY SORGHUM TYPE AND MATURITY (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	53.8[x]	47.8[tu]	48.3[w]	7.58	54.0[x]	53.5[xy]	.57
Wray	54.2[x]	48.8[tu]	48.4[w]	10.81	50.5[y]	48.9[z]	.98
ATx623x Rio	58.9[d,w]	48.2[e,tu]	39.4[f,x]	1.86	59.5[b,w]	52.5[c,y]	2.84
ATx623x Wray	60.5[d,w]	49.7[e,t]	46.5[f,w]	.37	59.3[b,w]	49.4[c,z]	5.19
ATx623x RTx430	58.5[d,w]	41.0[e,v]	41.0[e,x]	.12	58.9[w]	55.6[w]	1.08
ATx623x 74CS5388	60.8[d,w]	42.8[e,uv]	44.1[e,wx]	11.97	60.8[d,w]	54.9[e,wx]	.54

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ (P<.05).

[d,e,f] Means within harvest in same row with different superscripts differ (P<.01).

[t,u,v] Means in same column with different superscripts differ (P<.05).

[w,x,y,z] Means in same column with different superscripts differ (P<.01).

TABLE 15. NEUTRAL DETERGENT FIBER OF SORGHUM SILAGES FOR BOTH HARVESTS BY SORGHUM TYPE AND MATURITY (%)

	Harvest						
	Parent				Retoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	65.9[d]	53.3[e,wx]	53.3[e,w]	6.76	55.5	55.5[x]	.31
Wray	65.6[d]	54.9[e,w]	52.6[e,w]	2.11	59.1	52.7[y]	2.12
ATx623x Rio	62.8[d]	48.1[e,y]	47.6[e,x]	2.89	61.0	53.7[xy]	11.23
ATx623x Wray	63.8[d]	50.4[e,xy]	45.5[e,x]	5.68	62.1[b]	53.5[c,xy]	4.59
ATx623x RTx430	62.2[d]	40.4[e,z]	37.9[e,y]	3.96	61.2	58.8[w]	2.71
ATx623x 74CS5388	62.8[d]	42.0[e,z]	40.3[e,y]	2.11	61.3[d]	55.3[e,xy]	.32

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ (P<.05).

[d,e] Means within harvest in same row with different superscripts differ (P<.01).

[w,x,y,z] Means in same column with different superscripts differ (P<.01).

sorghums while the ADF of both types decreased (P<.05) at a lower rate for fresh sorghums. This may explain the type x maturity (P<.01) and type x harvest (P<.01) interactions of NDF at parent harvest and ADF at both harvests, and the type x maturity (P<.05) and type x harvest (P<.01) interactions of NDF at ratoon harvest (table 1A).

In general, differences in NDF and ADF occurred (P<.05) among sorghum types within any maturity stage at both harvests for both fresh and ensiled sorghums, except for NDF within A maturity at both harvests for ensiled sorghum and for ADF within SD maturity at ratoon harvest for fresh sorghum (tables 14, 15, 16 and 17).

During ensiling, there were no differences (P>.05) in NDF content for any sorghum type at any maturity stage of either harvest, except for Rio and Wray (P<.05) and ATx623xWray (P<.01) for the parent harvest, and ATx623xRio for the ratoon harvest at A maturity (table 5A). At SD maturity, NDF content increased for ATx623xWray (P<.01) and ATx623xRTx430 (P<.05) for the ratoon harvest with ATx623xRTx430 (P<.05) for the parent harvest at SD maturity also increasing (tables 6A and 7A). The NDF content of ATx623xRTx430 for both fresh and ensiled states and ATx623x74CS5388 for the ensiled state increased (P<.01) from the parent to the ratoon harvest at SD maturity, while NDF content of fresh ATx623x74CS5388 increased (P<.05) at a lower rate.

For the parent harvest, ADF of Rio (P<.05) and ATx623x74CS5388 (P<.01) increased at A maturity, while a

TABLE 16. ACID DETERGENT FIBER OF FRESH SORGHUMS FOR BOTH HARVESTS BY SORGHUM TYPE AND MATURITY (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	34.8[x]	30.3[vw]	30.4[y]	4.08	30.3[z]	31.0	.30
Wray	35.3[x]	32.5[v]	29.7[y]	9.58	29.1[z]	28.6	.26
ATx623x Rio	37.6[d,vw]	31.6[e,vw]	26.7[f,z]	.26	34.0[b,y]	29.7[c]	1.02
ATx623x Wray	39.2[d,v]	32.2[e,vw]	30.5[e,y]	1.28	34.2[b,y]	29.2[c]	1.22
ATx623x RTx430	36.5[d,wx]	25.4[e,x]	26.6[e,z]	1.42	34.8[b,y]	31.5[c]	.26
ATx623x 74CS5388	37.8[d,vw]	27.6[e,wx]	28.5[e,yz]	2.40	34.8[b,y]	30.2[c]	1.07

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ (P<.05).

[d,e,f] Means within harvest in same row with different superscripts differ (P<.01).

[v,w,x] Means in same column with different superscripts differ (P<.05).

[y,z] Means in same column with different superscripts differ (P<.01).

TABLE 17. ACID DETERGENT FIBER OF SORGHUM SILAGES FOR BOTH HARVESTS BY SORGHUM TYPE AND MATURITY (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	39.6[d,u]	30.9[e,x]	32.8[e,w]	.81	33.8[v]	34.2[uv]	.18
Wray	39.6[b,u]	34.2[c,w]	33.9[c,w]	.82	37.1[u]	32.8[v]	6.27
ATx623x Rio	38.2[d,v]	28.6[e,y]	29.8[e,x]	2.36	38.2[u]	32.7[v]	6.56
ATx623x Wray	39.5[d,u]	30.4[e,x]	29.0[e,x]	2.45	39.7[u]	33.9[v]	5.33
ATx623x RTx430	38.1[d,v]	24.0[e,z]	22.4[e,z]	1.54	38.2[u]	36.3[u]	.42
ATx623x 74CS5388	38.7[d,uv]	25.0[e,z]	24.7[e,y]	1.82	38.9[u]	34.3[uv]	2.30

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ (P<.05).

[d,e] Means within harvest in same row with different superscripts differ (P<.01).

[u,v] Means in same column with different superscripts differ (P<.05).

[w,x,y,z] Means in same column with different superscripts differ (P<.01).

decrease (P<.05) occurred for ATx623xRTx430 at SD and HD maturities and ATx623x74CS5388 at HD maturity during ensiling (tables 8A, 9A and 10A). In general, ADF content of all sorghum types increased (P<.05) during ensiling for the ratoon harvest except for ATx623xRTx430 at A maturity and Wray and ATx623xRio at SD maturity. Differences existed between harvests for fresh Rio, ATx623xRio, Atx623xWray and ATx623x74CS5388 (P<.05), and for ensiled Rio (P<.01) at A maturity. At SD maturity, ADF for fresh ATx623x74CS5388 (P<.05) and fresh and ensiled ATx623xRTx430 (P<.01) differed between parent and ratoon harvests.

The ADL content of Rio (P<.05) increased at parent harvest for fresh sorghum with advancing age with no differences for ensiled sweet sorghum types. At the ratoon harvest, ADL of Wray increased (P<.01) from A to SD maturity when fresh, while no changes (P>.05) occurred for ensiled sorghums (tables 18 and 19). Ash content of Rio and Wray increased (P<.05) as maturity advanced at both harvests for fresh and ensiled sorghums except for ensiled Rio at parent harvest and fresh and ensiled Wray at ratoon harvest (tables 20 and 21). The ADL content of ATx623x74CS5388 decreased (P<.05) as maturity advanced at the ratoon harvest of fresh sorghum, while the ADL content of ATx623xRTx430 decreased (P<.05) from A to SD maturity but remained constant until HD maturity at the parent harvest of ensiled sorghum. The ash content of fresh ATx623xRTx430 decreased (P<.05) from A to SD maturity while increased (P<.05) from SD to HD maturity at

TABLE 18. ACID DETERGENT LIGNIN OF FRESH SORGHUMS FOR BOTH HARVESTS BY SORGHUM TYPE AND MATURITY (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	3.3[c]	4.1[c,yz]	5.6[b,x]	.29	3.8[yz]	3.7[w]	.15
Wray	3.7	4.3[yz]	5.8[x]	.89	3.3[e,z]	3.7[d,w]	.001
ATx623x Rio	3.7[c]	6.2[b,x]	5.4[b,x]	.33	4.3[xy]	4.4[v]	.23
ATx623x Wray	3.8[c]	5.1[b,xy]	5.5[b,x]	.23	3.8[yz]	4.1[vw]	.04
ATx623x RTx430	3.6	3.2[z]	3.3[y]	.17	4.3[xy]	4.4[v]	.07
ATx623x 74CS5388	3.6	3.4[z]	3.7[y]	.10	4.6[b,x]	4.3[c,v]	.01

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ ($P<.05$).

[d,e] Means within harvest in same row with different superscripts differ ($P<.01$).

[v,w] Means in same column with different superscripts differ ($P<.05$).

[x,y,z] Means in same column with different superscripts differ ($P<.01$).

TABLE 19. ACID DETERGENT LIGNIN OF SORGHUM SILAGES FOR BOTH HARVESTS BY SORGHUM TYPE AND MATURITY (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	4.5	4.3[y]	4.1[y]	.32	3.2	3.5	.20
Wray	4.4	4.9[x]	4.0[y]	.35	3.5	3.4	.02
ATx623x Rio	3.8	5.0[x]	5.1[x]	.31	3.8	2.6	2.83
ATx623x Wray	4.4	4.9[x]	5.2[x]	.25	4.0	4.2	.44
ATx623x RTx430	4.4[b]	2.9[c,z]	2.9[c,z]	.29	4.5	4.5	.04
ATx623x 74CS5388	5.0	3.2[z]	3.3[yz]	.58	4.7	4.3	.02

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ ($P<.05$).

[x,y,z] Means in same column with different superscripts differ ($P<.01$).

the parent harvest. At the ratoon harvest, ash content of ensiled ATx623xRTx430 increased (P<.05) as maturity progressed. The ADL content of ATx623xRio at the parent harvest increased (P<.05) from A to SD maturity and then remained (P>.05) similar from SD to HD maturity for fresh sorghum. However, ADL content of ATx623xWray steadily increased (P<.05) with advancing maturity for fresh sorghum at the parent harvest. Ash content of fresh ATx623xRio increased (P<.05) with advancing maturity at the ratoon harvest. Ash content of ensiled sorghums increased for ATx623xRio (P<.05) as maturity progressed at the parent harvest; however, at the ratoon harvest, ash content of ATx623xRio decreased (P>.05). Thus the type x maturity and type x harvest interactions (P<.01) of fresh sorghums, and the type x harvest (P<.05) interaction of ensiled sorghums for ADL as well as the type x harvest (P<.05) interaction of ensiled sorghums for ash (table 1A) are rather involved.

In general, ADL content among sorghum types was different (P<.05) within SD and HD maturities at the parent harvest of both fresh and ensiled sorghums, and within A and SD maturities at the ratoon harvest of fresh sorghum. Differences in ash content among sorghum types occurred within A maturity at both harvests (P<.01) for fresh sorghum, and within A and SD maturities at parent harvest (P<.01) and SD maturity at ratoon harvest (P<.05) for ensiled sorghum.

Statistical analyses showed that no differences in ADL and ash content occurred (P>.05) during ensiling except for

TABLE 20. ASH CONTENT OF FRESH SORGHUMS FOR BOTH HARVESTS BY SORGHUM TYPE AND MATURITY (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	$1.9^{c,z}$	2.0^{c}	3.1^{b}	.24	$2.2^{c,y}$	3.0^{b}	.04
Wray	$1.6^{d,z}$	2.7^{c}	3.6^{b}	.24	2.1^{y}	2.7	.07
ATx623x Rio	2.7^{y}	3.1	2.6	.24	$2.3^{c,y}$	2.7^{b}	.01
ATx623x Wray	2.8^{xy}	2.8	2.8	.24	2.9^{x}	3.1	.65
ATx623x RTx430	$3.1^{bc,xy}$	2.4^{c}	3.6^{b}	.24	3.3^{x}	4.0	.13
ATx623x 74CS5388	3.3^{x}	2.7	3.5	.24	3.0^{x}	3.6	.16

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c,d] Means within harvest in same row with different superscripts differ (P<.05).

[x,y,z] Means in same column with different superscripts differ (P<.01).

TABLE 21. ASH CONTENT OF SORGHUM SILAGES FOR BOTH HARVESTS BY SORGHUM TYPE AND MATURITY (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	2.2^{yz}	2.0^{z}	4.7	1.35	3.1^{c}	$4.0^{b,u}$	.001
Wray	$2.1^{c,z}$	$2.7^{c,y}$	5.3^{b}	.42	3.2	3.4^{uv}	.48
ATx623x Rio	$2.5^{c,xy}$	$3.1^{bc,wx}$	3.5^{b}	.07	3.3	2.1^{v}	1.93
ATx623x Wray	2.8^{wx}	3.1^{w}	3.3	.05	3.6	4.0^{u}	.16
ATx623x RTx430	3.0^{w}	2.7^{xy}	3.4	.13	4.0^{c}	$5.0^{b,u}$	.04
ATx623x 74CS5388	3.0^{w}	2.9^{wxy}	3.3	.27	4.0	4.2^{u}	.59

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ (P<.05).

[u,v] Means in same column with different superscripts differ (P<.05).

[w,x,y,z] Means in same column with different superscripts differ (P<.01).

ADL content of ATx623xRTx430 that increased ($P<.05$) at A maturity, and Rio and Wray that decreased ($P<.05$) at HD maturity for the parent harvest. Ash content of ATx623xRTx430, ATx623xRio and Wray also increased ($P<.05$) at A maturity for the ratoon harvest (tables 11A, 12A, 13A, 14A, 15A and 16A).

Data of Danley and Vetter (1973) indicated that ensiled forage sorghums had higher ($P<.01$) ADF, cellulose and lignin content than fresh sorghums due to lower ($P<.01$) soluble carbohydrates, estimated digestible energy and estimated total digestible nutrients. Lignin content of sorghums increased with advancing maturity for both parent and ratoon harvests but their composition was similar for both harvests (Aii, 1975). Suarez (1976) found an increase ($P<.01$) in lignin content of the whole plant forage and grain-type sorghums with advancing maturity which agrees with the data of Achacoso et al. (1960) and Allinson (1969). However, Suarez (1976) found a non-significant increase in ash content of sorghums which disagrees with the data of Eilrich et al. (1964) and Johnson et al. (1968).

In vitro dry matter digestibility. Contrary to most findings with sorghum silages (Owen, 1962; Browning and Lusk, 1967; Danley and Vetter, 1973; Suarez, 1976; Black et al., 1980) in which dry matter digestibility decreased with advancing maturity, IVDMD increased ($P<.01$) as maturity advanced for both fresh and ensiled sorghums (tables 5 and 7), but decreased ($P>.05$) slightly with the ratoon harvest.

Type of sorghums also influenced (P<.05) IVDMD with the high energy type being the least for both fresh and ensiled states (P<.05) and (P<.01), respectively (tables 4 and 6).

Sweet sorghum types had the highest (P<.05) IVDMD at A maturity while the high grain types were the highest (P<.05) at HD maturity, with no differences (P>.05) at SD maturity for the parent harvest of fresh sorghum (table 22). At the ratoon harvest, IVDMD of sweet types was the highest for A maturity (P<.01) of fresh and ensiled sorghums and SD maturity (P<.05) of fresh sorghum. However, IVDMD of ensiled high grain sorghums was greatest (P<.01) among sorghum types for any maturity stage at the parent harvest (table 23). This was illustrated by the type x maturity (P<.05) and type x harvest (P<.01) interactions for fresh sorghums, and the type x harvest (P<.01) interaction of ensiled sorghums (table 1A). In general, high grain sorghum increased (P<.01) in IVDMD with advancing maturity for both fresh and ensiled states at the parent harvest except for fresh ATx623xRTx430 due to an increase in the highly digestible grain content. However, at the ratoon harvest, the fresh and ensiled IVDMD of high grain types was lower (P>.05), probably due to lower grain yield. Sweet and high energy sorghums had different IVDMD trends than high grain types (tables 17A, 18A and 19A). Statistical analyses indicated no differences (P>.05) in IVDMD with advancing maturity for Rio, Wray and ATx623xWray of both fresh and ensiled states, whereas differences were present for fresh ATx623xRio (P<.05) and ensiled Rio (P<.01).

TABLE 22. IN VITRO DRY MATTER DIGESTIBILITY OF FRESH SORGHUMS FOR BOTH HARVESTS BY SORGHUM TYPE AND MATURITY (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	75.5^{u}	73.7	74.2^{vw}	8.54	75.0^{x}	76.5^{u}	.60
Wray	74.4^{uv}	73.6	73.2^{vw}	9.24	76.3^{x}	77.0^{u}	1.03
ATx623x Rio	73.1^{c,vw}	71.3^{c}	77.0^{b,uv}	1.58	70.7^{yz}	73.2^{v}	1.80
ATx623x Wray	71.7^{w}	69.4	72.6^{w}	5.05	71.7^{e,y}	74.6^{d,uv}	.01
ATx623x RTx430	73.8^{uvw}	76.9	78.9^{u}	3.76	71.1^{yz}	72.5^{v}	.83
ATx623x 74CS5388	72.4^{c,vw}	75.0^{bc}	77.2^{b,uv}	1.82	69.5^{z}	73.0^{v}	3.41

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ (P<.05).

[d,e] Means within harvest in same row with different superscripts differ (P<.01).

[u,v,w] Means in same column with different superscripts differ (P<.05).

[x,y,z] Means in same column with different superscripts differ (P<.01).

Differences in quantity and quality of available carbohydrates of each group may have accounted for the different trends that occurred in IVDMD as maturity advanced for each type of sorghum. At the ratoon harvest, IVDMD increased ($P<.01$) for fresh ATx623xWray and ensiled ATx623xRio while all of the other types were unaffected ($P>.05$) with advancing maturity.

A decrease in IVDMD occurred during ensiling of ATx623xRio and Rio for A ($P<.01$) and HD ($P<.05$) maturities and ATx623x74CS5388 for A ($P<.05$) maturity at the parent harvest, while IVDMD of ATx623xRTx430 decreased ($P<.05$) at the ratoon harvest for A and SD maturities. Differences in IVDMD occurred between harvests of ensiled ATx623xRio ($P<.05$) and Rio ($P<.01$) for A maturity, and AT623xRTx430 and ATx623x74CS5388 ($P<.01$) for SD maturity which may explain the maturity x harvest ($P<.01$) interaction of silage.

Owen (1967) indicated that forage sorghums declined continuously in DM digestibility with increased age due to compositional changes of their cell wall constituents, while the opposite occurred for those with high grain content, apparently due to the rapid increase during maturation in the amount of highly digestible starch. Kuhlman and Owen (1962) reported that a high grain sorghum was more digestible at the medium and hard dough stages than Atlas sorghum silage with DM digestibility decreasing from 61 to 52% as maturity advanced. However, they found that at the milk stage, both high grain and sweet sorghum silages had equal DM

TABLE 23. IN VITRO DRY MATTER DIGESTIBILITY OF SORGHUM SILAGES FOR BOTH HARVESTS BY SORGHUM TYPE AND MATURITY (%)

	Harvest						
	Parent				Ratoon		
	Maturity^{a}				Maturity^{a}		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	$67.9^{d,x}$	$73.5^{b,xy}$	$70.2^{c,x}$	1.04	76.0^{w}	72.7	4.33
Wray	67.5^{xy}	69.2^{z}	70.6^{x}	4.29	73.8^{w}	74.0	1.48
ATx623x Rio	65.4^{y}	70.6^{yz}	70.1^{x}	4.75	$70.5^{c,x}$	71.6^{b}	.02
ATx623x Wray	67.5^{xy}	69.7^{z}	71.1^{x}	3.12	69.0^{x}	69.8	2.88
ATx623x RTx430	$71.1^{c,w}$	$78.2^{b,w}$	$78.3^{b,w}$	0.56	69.1^{x}	68.4	.57
ATx623x 74CS5388	$69.4^{c,wx}$	$76.7^{b,wx}$	$76.9^{b,w}$	.63	69.0^{x}	70.2	1.87

^{a} Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

^{b,c,d} Means within harvest in same row with different superscripts differ (P<.01).

^{w,x,y,z} Means in same column with different superscripts differ (P<.01).

digestibility which disagrees with data in the current experiment. Suarez (1976) reported a decrease ($P<.01$) in IVDMD with advancing maturity of ORO-t, a tall high grain sorghum, and FS-1b, a intermediate height forage sorghum, cultured at two different locations.

Limited information regarding the total carbohydrate content of the varieties used in this trial is available, and even less is available about their compositional changes with advancing maturity at ratoon harvest. Miller and Creelman (1980) reported total soluble carbohydrates and grain yields of 6393 and 733, 7632 and 1725, 9906 and 5897, 9761 and 8847, and 5493 and 5065 kg/ha for Wray, Rio and ATx623xRio, ATx623xRTx430 and ATx623x74CS5388, respectively. Therefore, grain yield accounted for a 11.5%, and 22.6, 55.5, and 90.6% and 92.2% of the total soluble carbohydrates in sweet, high energy and high grain sorghum types, which may explain the increase in IVDMD with increasing age.

Organic acids and ethanol. Available data on organic acids and ethanol content of sorghum silage have seldom been cited in the literature. However, some experiments have been conducted within the last 5 years that show different results (Megehee, 1979; Suarez, 1976; Black et al., 1980).

Statistical analyses of the current experiment show that lactic acid was influenced by maturity ($P<.01$) and harvest ($P<.05$) with acetic acid influenced by sorghum type ($P<.05$), maturity ($P<.01$) and harvest ($P<.05$) as shown in tables 24 and 25. Ethanol was only influenced by sorghum type ($P<.01$)

TABLE 24. ORGANIC ACIDS AND ETHANOL OF SORGHUM SILAGES BY SORGHUM TYPE

	Type						
Variable, %	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388	MSE
Lactic	7.8	9.2	8.3	9.1	8.5	7.7	2.05
Acetic	1.2[b]	1.4[a]	1.2[b]	1.4[a]	1.2[b]	1.3[ab]	.03
Propionic	0	0	.01	0	.03	.01	.004
Butyric	0	0	0	0	0	0	0
Ethanol	4.7[c]	6.1[c]	1.9[d]	2.3[d]	1.6[d]	1.4[d]	3.44

[a,b] Means in same row with different superscripts differ (P<.05).

[c,d] Means in same row with different superscripts differ (P<.01).

TABLE 25. ORGANIC ACIDS AND ETHANOL OF SORGHUM SILAGES BY MATURITY AND HARVEST

	Maturity				Harvest		
Variable, %	Anthesis, 50%	Soft dough	Hard dough	MSE	Parent	Ratoon	MSE
Lactic	9.9[c]	7.5[d]	7.3[d]	.84	8.43[a]	8.38[b]	1.46
Acetic	1.5[c]	1.2[d]	1.0[e]	.03	1.5[c]	1.2[d]	.09
Propionic	.02	0	.01	.002	.02	0	.003
Butyric	0	0	0	0	0	0	0
Ethanol	3.0	2.9	3.1	1.40	2.6[b]	3.5[a]	1.88

[a,b] Means within maturity in same row with different superscripts differ (P<.05).

[c,d,e] Means within maturity in same row with different superscripts differ (P<.01).

and harvest ($P<.05$). Butyric acid was not detected in any silage indicating favorable fermentation. Lactic acid decreased with advancing maturity ($P<.01$) and from parent to ratoon harvest ($P<.05$), with acetic acid also decreasing ($P<.01$) as maturity progressed and from parent to ratoon harvest. However, ethanol increased ($P<.05$) from parent to ratoon harvest.

At parent harvest, lactic acid content for Rio ($P<.01$), ATx623xRio ($P<.05$), ATx623xWray ($P<.01$) and ATx623x74CS5388 ($P<.05$) decreased from A to SD maturity but remained similar from SD to HD maturity (table 26). Lactic acid content for high energy sorghums and Wray decreased ($P<.05$) from A to SD maturity at the ratoon harvest. Differences ($P<.01$) in lactic acid among sorghum types within stage of maturity occurred for all maturities at either harvest, except for A maturity at the parent harvest. This may explain the type x harvest and maturity x harvest interactions ($P<.01$) of lactic acid (table 20A). Differences between harvests only occurred at SD maturity for Rio ($P<.05$), ATx623xRio ($P<.01$), ATx623xRTx430 ($P<.01$) and ATx623x74CS5388 ($P<.05$).

Acetic acid decreased ($P<.05$) from A to SD maturity and remained similar from SD to HD maturity at the parent harvest for ATx623xRio and ATx623x74CS5388 (table 27). At ratoon harvest, only the mean acetic acid for ATx623xRTx430 decreased ($P<.05$) from A to SD maturity. Differences in acetic acid among sorghum types within stage of maturity were found for A ($P<.05$) and SD ($P<.01$) maturities at the parent

TABLE 26. LACTIC ACID CONTENT FOR BOTH HARVESTS BY SORGHUM TYPE, MATURITY AND HARVEST (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	11.6[d,m]	7.8[e,k,x]	7.4[e,x]	.25	6.3[n,y]	6.0[l,z]	.71
Wray	10.3	9.5[w]	9.7[w]	1.08	9.4[b,wx]	7.4[c,y]	.30
ATx623x Rio	10.9[b]	5.8[c,n,z]	7.0[c,x]	2.59	9.9[b,wx]	7.9[c,m,xy]	.20
ATx623x Wray	11.5[d]	7.4[e,xy]	6.4[e,x]	.36	10.7[b,w]	8.5[c,x]	.12
ATx623x RTx430	10.8	6.5[n,yz]	6.6[x]	2.90	9.0[wx]	9.3[m,w]	.33
ATx623x 74CS5388	10.0[b]	6.2[c,l,z]	6.2[c,x]	1.57	8.6[x]	7.7[k,xy]	.03

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ (P<.05).

[d,e] Means within harvest in same row with different superscripts differ (P<.01).

[k,l] Means between harvests in same row with different superscripts differ (P<.05).

[m,n] Means between harvests in same row with different superscripts differ (P<.01).

[w,x,y,z] Means in same column with different superscripts differ (P<.01).

TABLE 27. ACETIC ACID CONTENT FOR BOTH HARVESTS BY SORGHUM TYPE, MATURITY AND HARVEST (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	.9[n,v]	1.0[l,xy]	.9	.01	1.7[m]	1.4[k,v]	.009
Wray	1.3[uv]	1.5[w]	1.2	.06	1.5	1.8[u]	.03
ATx623x Rio	1.8[b,m,u]	.8[c,l,yz]	.9[c]	.03	1.2[n]	1.4[k,v]	.01
ATx623x Wray	1.7[u]	1.1[x]	1.2	.06	1.6	1.5[v]	.09
ATx623x RTx430	1.3[uv]	.7[n,z]	.9	.12	1.7[b]	1.4[c,m,v]	.0003
ATx623x 74CS5388	1.9[b,u]	.8[c,n,yz]	.9[c]	.03	1.6	1.5[m,v]	.009

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ (P<.01).

[k,l] Means between harvests in same row with different superscripts differ (P<.05).

[m,n] Means between harvests in same row with different superscripts differ (P<.01).

[u,v] Means in same column with different superscripts superscripts differ (P<.05).

[w,x,y,z] Means in same column with different superscripts differ (P<.01).

TABLE 28. PROPIONIC ACID CONTENT FOR BOTH HARVESTS BY SORGHUM TYPE, MATURITY AND HARVEST (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	0	0	0	0	0	0	0
Wray	0	0	0	0	0	0	0
ATx623x Rio	.07	0	0	.005	0	0	0
ATx623x Wray	0	0	0	0	0	0	0
ATx623x RTx430	.11	0	.04	.009	0	0	0
ATx623x 74CS5388	.06	0	0	.004	0	0	0

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

harvest and SD maturity ($P<.05$) at the ratoon harvest. This may explain the type x maturity and maturity x harvest interactions ($P<.01$) of acetic acid (table 20A). Differences between harvests existed for ATx623xRio ($P<.01$) at A maturity and for Rio ($P<.05$), ATx623xRTx430 ($P<.01$) and ATx623x74CS588 ($P<.01$) at SD maturity.

Propionic acid was only detected for ATx623xRio, ATx623xRTx430 and ATx623x74CS5388 at A maturity, and ATx623xRTx430 at SD maturity for the parent harvest (table 28).

Ethanol content for high energy sorghums increased ($P<.01$) from A to HD maturity, while for ATx623xRTx430 remained similar from A to SD maturity but decreased ($P<.05$) from SD to HD maturity at parent harvest (table 29). At ratoon harvest, ethanol for Rio decreased ($P<.05$) and for ATx623xRTx430 increased ($P<.05$) from A to SD maturity. This may explain the type x maturity and type x harvest interactions ($P<.01$) for ethanol content (table 20A). At parent harvest, ethanol content of sweet sorghum silages was the highest ($P<.01$) at any maturity stage with ethanol content of the high grain being the least at HD maturity. At ratoon harvest, ethanol content of Wray was the highest ($P<.05$) at A and SD maturities. In general, differences ($P<.05$) in ethanol levels existed between harvests for all sorghum types at either A or SD maturity, except for Rio at A maturity, Wray at A and SD maturities, and ATx623x74CS5388 at A maturity.

TABLE 29. ETHANOL CONTENT FOR BOTH HARVESTS BY SORGHUM TYPE, MATURITY AND HARVEST (%)

	Harvest						
	Parent				Ratoon		
	Maturity[a]				Maturity[a]		
Type	A	SD	HD	MSE	A	SD	MSE
Rio	7.7[w]	5.9[m,w]	4.3[x]	6.87	3.1[b,v]	2.3[c,n,v]	.01
Wray	5.4[w]	5.0[x]	6.6[w]	2.91	8.5[u]	4.9[u]	4.90
ATx623x Rio	.1[f,l,x]	1.0[e,n,yz]	2.8[d,xy]	.05	3.2[k,v]	2.5[m,v]	1.82
ATx623x Wray	.2[f,l,x]	1.7[e,l,y]	2.7[d,xy]	.12	3.1[k,v]	4.0[k,uv]	1.82
ATx623x RTx430	.9[b,l,x]	.9[b,n,yz]	.6[c,z]	.005	1.8[c,k,v]	3.8[b,m,uv]	.09
ATx623x 74CS5388	.4[x]	.7[l,z]	1.3[yz]	.21	2.6[v]	2.5[k,v]	.04

[a] Maturity code: A= 50% anthesis, SD= Soft dough and HD= Hard dough.

[b,c] Means within harvest in same row with different superscripts differ (P<.05).

[d,e,f] Means within harvest in same row with different superscripts differ (P<.01).

[k,l] Means between harvests in same row with different superscripts differ (P<.05).

[m,n] Means between harvests in same row with different superscripts differ (P<.01).

[u,v] Means in same column with different superscripts differ (P<.05).

[w,x,y,z] Means in same column with different superscripts differ (P<.01).

Data of Black et al. (1980) indicated that lactic acid dropped significantly from the early dough to the hard dough maturity stage. Acetic acid did not change ($P>.05$) with advancing maturity, propionic acid was detected after the dough stage and butyric acid was not detected during any maturity stage which agree with the current data except for changes ($P<.01$) in acetic acid content. The mean of lactic and acetic acids and ethanol content, according to Megehee, (1979), were higher ($P<.01$) for sweet than for intermediate and grain-type sorghum after 21 d of ensiling with no propionic or butyric acids reported. The mean percentage of acetic and propionic acids did not differ ($P>.05$) between whole plant silage of an intermediate and a grain sorghum reported by Suarez (1976), while a decline ($P<.01$) was observed with advancing maturity with only negligible concentrations of butyric acid. The normal preservation of any ensiled forage is largely dependent on the rapid acidification of the medium by lactic acid (Sprague and Leparulo, 1965) and a 15% soluble carbohydrate minimum is required for adequate fermentation of forage and grain-type sorghums (Johnson et al., 1968).

Exp. 2

Acid detergent fiber. Differences in ADF content of sorghum silages occurred ($P<.01$) among diets (table 30) with means of 31.0, 29.6 and 23.0% for Wray, ATx623xRIO and ATx623xRTx430, respectively. Mean ADF differed ($P<.05$) among

TABLE 30. ACID DETERGENT FIBER, DRY MATTER INTAKE AND IN VIVO DIGESTIBILITY OF SORGHUM SILAGES

	Diet			
Variable	Wray	ATx623 x Rio	ATx623 x RTx430	MSE
Acid detergent fiber, %	31.0^{a}	29.6^{b}	23.0^{c}	.73
Dry matter intake, kg/d	3.9^{c}	5.0^{b}	5.6^{a}	.16
	In vivo digestibility, %			
Dry matter	68.1^{a}	65.0^{b}	69.5^{a}	7.69
Acid detergent fiber	55.7^{a}	46.0^{b}	51.8^{a}	14.36

[a,b,c] Means in same row with different superscripts differ (P<.01).

diets at either harvest (table 31). The high energy diet ($P<.05$) increased at a lower rate from the parent to the ratoon harvest than the high grain diet ($P<.01$). In general, the ADF content of sorghum silages in this trial followed the same trend observed in Exp. 1, in which mean ADF increased from the parent to the ratoon harvest, probably due to a decrease in grain content of silages. Lutrick and Prine (1968) reported that ratoon grain sorghum varieties yielded slightly more than 50% of the parent harvest.

Dry matter intake. The average dry matter intake (DMI) was influenced ($P<.01$) by diet (table 30). Mean DMI was 3.9, 5.0 and 5.6 kg for Wray, ATx623xRio and ATx623xRTx430, respectively. Differences in DMI (table 31) among diets existed at parent harvest ($P<.01$) but not at ratoon harvest ($P>.05$). The DMI was higher for ATx623xRio ($P<.05$) at ratoon than at parent harvest even though the dry matter content of both diets was lower for ratoon than parent harvest (29.78 and 34.19%, respectively). This may be explained in part because the stockers used in this trial were still growing, thus they ate more dry matter while consuming ratoon than parent silages. Available data (Owen, 1967; Browning and Lusk, 1967; Black et al., 1980) indicate that dry matter intake of sorghum silage generally increases with advancing maturity. However, no data were found in the literature regarding the ratooning effect on dry matter intake. Garrett and Worker (1965) reported that silage dry matter intake of animals fed sweet and forage sorghums ad libitum was not

TABLE 31. ACID DETERGENT FIBER, DRY MATTER INTAKE AND IN VIVO DIGESTIBILITY OF SORGHUM SILAGES BY DIET AND HARVEST

	Harvest						
	Parent				Ratoon		
	Diet				Diet		
Variable	Wray	ATx623 x Rio	ATx623 x RTx430	MSE	ATx623 x Rio	ATx623 x RTx430	MSE
Acid detergent fiber, %	31.0^{c}	28.9^{d,x}	20.2^{e,z}	2.48	30.7^{c,w}	27.1^{d,y}	.04
Dry matter intake, kg/d	3.9^{d}	4.5^{cd,x}	5.2^{c}	.26	5.6^{w}	6.1	.14
			In vivo digestibility, %				
Dry matter	68.1	67.6^{w}	70.2	17.99	61.0^{b,x}	68.5^{a}	5.26
Acid detergent fiber	55.7	49.0^{w}	50.2	52.21	41.5^{b,x}	54.1^{a}	19.87

[a,b] Means within harvest in same row with different superscripts differ ($P<.05$).

[c,d,e] Means within harvest in same row with different superscripts differ ($P<.01$).

[w,x] Means between harvests in same row with different superscripts differ ($P<.05$).

[y,z] Means between harvests in same row with different superscripts differ ($P<.01$).

different (P>.05).

<u>In vivo digestibility.</u> Both dry matter digestibility (DMD) and acid detergent fiber digestibility (ADFD) differed (P<.01) among diets (table 30). The DMD and ADF of Wray and ATx623xRTx430 were not different (P>.05) from each other, but they were higher (P<.01) than those of ATx623xRio (68.1 and 55.7%, 69.5 and 51.8% and 65.0 and 46.0% for DMD and ADFD of Wray, ATx623xRTx430 and ATx623xRio, respectively). However, when the data were analyzed by harvest, mean DMD and ADFD did not differ (P>.05) among diets at parent harvest, but both DMD and ADFD were different (P<.05) at ratoon harvest (table 31). The high energy diet had lower (P<.05) DMD and ADFD at ratoon harvest than the high grain diet.

Differences (P<.05) between harvests existed in DMD (table 31) of ATx623xRio. Mean DMD was 67.6 and 61.0% for ATx623xRio and 70.2 and 68.5% for ATx623xRTx430 at parent and ratoon harvests, respectively. This may be explained by a decrease in grain content of the silage from parent to ratoon harvest. Ratoon grain sorghum varieties have been reported to yield slightly more than 50% of the first harvest (Lutrick and Prine, 1968). Others (Escalada and Plucknet, 1975) have reported that tall sorghum plants produce greater stover yields than shorter sorghums. Data of Fernandez et al. (1982) indicated higher digestibility values from the ratoon sorghum grain silages than from the parent harvest when fed to lactating dairy cows due to improvement in starch digestibility of the regrowth harvested at an earlier stage of maturity than the parent harvest.

The ADFD of ATx623xRio (table 31) was higher (P<.05) for the parent than for the ratoon harvest (49.0 and 41.5%, respectively), while ATx623xRTx430 did not differ (P>.05) from the parent to the ratoon harvest (50.2 and 54.1%, respectively). This may explain the diet x harvest interaction (P<.05) of ADFD which was likely due to a seasonal effect on the ratoon high grain sorghum. Regrowth culms are usually thinner and more flexible than first-growth culms, thus less differentiated tissues in the regrowth are more digestible (Fribourg et al., 1976). They concluded that achieving efficient production of digestible dry matter from forages sorghums was related to the interactions among species and cultivars, defoliation or cutting intensity and frequency, and enviromental factors impinging on the plants.

A correlation coefficient (P<.10) of (r= .989) in vitro dry matter digestibility with in vivo dry matter digestibility suggested that in vitro techniques may satisfactorily be used to screen sorghums for in vivo digestibility. Schmid et al. (1975), working with grain and sweet sorghums, also found a high correlation (r= .91) between in vitro and in vivo DM digestibility.

The temperature of silage was not influenced (P>.05) by sorghum type. Mean temperature was 30.5, 30.2 and 31.8 C for Wray, ATx623xRio and ATx623xRTx430, respectively.

Exp. 3

Although dry matter content, pH, in vitro dry matter digestibility and acetic acid were influenced ($P<.05$) by treatment, no differences ($P>.05$) between control and treated silages were observed (table 32). However, there was an indication that Silamix reduced seepage loss when added to sorghum silage (210.6 vs 190.7 ml for control and Silamix, respectively). Dry matter content and dry matter recovery of Silamix treated sorghum silages was similar to control. Temperature between sorghum silages were not influenced ($P>.05$) by Silamix. The DM content was higher ($P<.05$) and pH lower ($P<.01$) for fresh sorghum than for control and treated sorghum silages with no differences ($P>.05$) between the two silages. In vitro dry matter digestibility was higher ($P<.05$) for fresh than for ensiled sorghums (80.2 vs 76.8 and 76.6% for fresh, control and Silamix, respectively). Mean acetic and propionic acid content was higher in this experiment than in Exp. 1, though no statistical analyses were performed to establish a comparison. Acetic acid was higher ($P<.01$) for fresh than for ensiled treatments with no differences ($P>.05$) between control and Silamix treated sorghum silages. Percentage of propionic and butyric acid were not different ($P>.05$) among treatments. However, Silamix treated sorghum silage had a non-significant lower butyric acid content, which may be an indication that Silamix helped to preserve sorghum silage.

In general, it was concluded that Silamix was of no

TABLE 32. EFFECT OF A SILAGE ADDITIVE ON SORGHUM SILAGES

Variable	Treatment: Fresh	Control	Silamix[a]	MSE
Dry matter, %	31.3[b]	29.2[c]	29.9[c]	.76
Dry matter recovery, %		86.7	88.8	14.40
pH	5.15[d]	3.51[e]	3.56[e]	.02
Temperature, C		23.3	23.8	32.98
Seepage, ml/30 d		210.6	190.7	3291.52
In vitro dry matter digestibility, %	80.2[b]	76.8[c]	76.6[c]	3.27
Acetic acid, %	.03[c]	1.83[b]	2.02[b]	1.62
Propionic acid, %	.0038	.0043	.0042	.0001
Butyric acid, %	.040	.068	.036	.003

[a] Registered trade name of Ralco-mix products, Inc. Marshall, MN 56258.

[b,c] Means in same row with different superscripts differ ($P<.05$).

[d,e] Means in same row with different superscripts differ ($P<.01$).

benefit for commercial production of sorghums, since dry matter recovery, seepage loss and in vitro dry matter digestibility were not different (P>.05) between control and Silamix treated sorghum silages. The height of the experimental silos and volume of silage used could influence these results compared to commercially available silos that are much larger (Gordon, 1967).

SUMMARY AND CONCLUSIONS

Exp. 1

The objective of this experiment was to determine changes in dry matter yield, ensiling characteristics and losses, chemical composition and in vitro dry matter digestibility of two sweet, two high energy and two high grain sorghum silages harvested at 50% anthesis, soft dough and hard dough stages of maturity for both parent and ratoon harvests.

Dry matter content (DM) and dry matter yield (DMY) significantly increased as maturity advanced for both fresh and ensiled sorghums. Individually, DM content was higher and DMY was lower for parent than for ratoon harvest. As expected, DM content was lower for ensiled than for fresh sorghums. Mean DMY was different among sorghum types at any maturity stage except at the hard dough stage for the parent harvest.

Significant decreases in dry matter ensiling losses (DMEL), seepage and temperature occurred with advancing maturity and from parent to ratoon harvest, except for temperature which increased from soft dough to hard dough maturity. No seepage occurred at soft dough maturity for the ratoon harvest. The experimental silos were placed in an ambient temperature room and enviromental temperature influenced internal temperature of silage.

In general, neutral detergent fiber (NDF) and acid detergent fiber (ADF) of both fresh and ensiled sorghums decreased with advancing maturity and from parent to ratoon harvest except for fresh sweet sorghums. No significant changes in NDF and ADF occurred from soft dough to hard dough maturity for the parent harvest. Significant differences in NDF and ADF existed among sorghum types at any maturity stage of both fresh and ensiled sorghums for either harvest. There was a trend for NDF and ADF to increase during ensiling at any maturity stage for either harvest. Microbial fermentation may have been responsible for this trend since soluble carbohydrates would be used for production of lactic acid to preserve silage.

Acid detergent lignin (ADL) of ensiled sorghums and ash content of fresh sorghums significantly increased with advancing maturity at parent harvest, except for the high grain sorghums. At ratoon harvest, there were few significant changes in ADL for both fresh and ensiled sorghums, whereas ash increased with advancing maturity.

In vitro dry matter digestibility (IVDMD) significantly increased as maturity advanced for both fresh and ensiled sorghums but slightly decreased from parent to ratoon harvest. Sweet and high energy sorghums had a different trend than high grain types with the high grain sorghums significantly increasing with advancing maturity in both fresh and ensiled states at parent harvest, while sweet and high energy sorghums decreased from 50% anthesis to soft dough and increased thereafter for fresh sorghums, and slightly increasing with advancing maturity for sorghum silages.

In general, no significant differences in IVDMD existed between the soft dough and hard dough maturity stages for any sorghum type at either harvest. As expected, a decrease in IVDMD occurred during ensiling. Mean IVDMD of high grain sorghum silages was significantly lower for ratoon than for parent harvest at soft dough maturity probably due to a lower in grain yield.

Silage lactic and acetic acids significantly decreased with advancing maturity and from parent to ratoon harvest. Propionic acid was only detected in high grain sorghum silages at 50% anthesis and soft dough maturities for the parent harvest. Butyric acid was not detected in any silage indicating favorable fermentation. Ethanol significantly increased from parent to ratoon harvest. Mean ethanol was higher for the sweet than for the high energy and high grain sorghum silages for either harvest. Thus proper ensiling conditions must be established with sweet sorghums if an alcohol fermentation is to be averted.

Exp. 2

This experiment was designed to establish in vivo dry matter and acid detergent fiber digestibility of a sweet, a high energy and a high grain sorghum silages for both parent and ratoon harvests at the hard dough stage of maturity.

Acid detergent fiber was significantly higher for the sweet and high energy diets than for the high grain diet. A significant increase in ADF of both high energy and high grain diets occurred from parent to ratoon harvest, following the same trend as in Exp. 1. Differences in dry matter intake (DMI) existed among diets for parent harvest with the high energy and high grain diets having higher DMI than the sweet silage diet.

Dry matter digestibility (DMD) and acid detergent fiber digestibility (ADFD) were not significantly different among diets for the parent harvest. However, for the ratoon harvest, the high grain diet had higher DMD and ADFD than the high energy diet. Mean DMD and ADFD of the high energy diet was significantly lower for the ratoon than for the parent harvest, this change was not significant for the high grain diet, probably due to a decrease in grain content of silage.

A correlation coefficient of (r= .989) in vitro dry matter digestibility with in vivo dry matter digestibility suggested that in vitro techniques may satisfactorily be used to screen sorghums for in vivo digestibility. The temperature of silage was not influenced by sorghum type.

Exp. 3

The objective of this experiment was to evaluate the effect of Silamix, a commercial silage additive, upon ensiling characteristics and in vitro dry matter digestibility of sorghum silages.

Dry matter and dry matter recovery of Silamix treated sorghum silages was similar to control. The pH was lower and IVDMD and acetic acid were higher for fresh than for ensiled sorghums with non-significant differences between control and Silamix treated sorghum silages. Seepage was similar for both silage treatments. Propionic and butyric acids did not differ between silage treatments.

Silamix did not significantly alter sorghum silage preservation in this experiment since DM recovery, seepage and IVDMD were not significantly different between control and Silamix treated silages.

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TABLE 1A. FRESH SORGHUM AND SORGHUM SILAGE INTERACTIONS

	Fresh			Silage		
Variable	TYPE * MAT[1]	TYPE * HARV[2]	MAT * HARV[3]	TYPE * MAT[1]	TYPE * HARV[2]	MAT * HARV[3]
	Level of probability					
Dry matter	.01	NS	.01	.01	.05	.01
Dry matter yield	NS	NS	.01	NS	NS	NS
Dry matter loss	NS	NS	NS	NS	.01	NS
Seepage	NS	NS	NS	.01	.01	.01
Temperature	NS	NS	NS	.01	.01	NS
Dry matter digestibility	.05	.01	.05	NS	.01	.01
Neutral detergent fiber	.01	.01	.01	.05	.01	.01
Acid detergent fiber	.01	.01	.01	.01	.01	.01
Acid detergent lignin	.01	.01	.05	NS	.05	NS
Ash	NS	.05	NS	NS	.05	NS

[1] Type * maturity.

[2] Type * harvest.

[3] Maturity * harvest.

TABLE 2A. DRY MATTER OF FRESH AND ENSILED SORGHUMS AT 50% ANTHESIS STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	23.9[b]	21.8	21.2[d]	20.4	22.8	22.1
	Ensiled	21.8[b]	21.3	22.8[d]	21.8[b]	22.7	21.6[d]
	MSE	6.39	.50	.38	.74	.77	1.51
Ratoon							
	Fresh	30.0[a]	27.3[a]	26.6[c]	24.6	27.4	27.3
	Ensiled	28.3[a]	24.5[b]	25.4[c]	24.8[a]	26.3	26.7[c]
	MSE	.53	.36	.38	.77	.88	.18

[a,b] Means in same column with different superscripts differ (P<.05).

[c,d] Means in same column with different superscripts differ (P<.01).

TABLE 3A. DRY MATTER OF FRESH AND ENSILED SORGHUMS AT SOFT DOUGH STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	34.5	27.8^{b}	30.5	27.9^{b}	33.4	34.8^{a}
	Ensiled	31.2	27.1^{b}	31.3	29.0^{b}	32.4	33.7
	MSE	1.88	.04	.38	.34	1.37	1.28
Ratoon							
	Fresh	36.0	32.1^{a}	34.2^{a}	34.0^{a}	34.1^{a}	33.9^{b}
	Ensiled	33.9	30.8^{a}	32.3^{b}	31.6^{a}	31.7^{b}	33.6
	MSE	.50	.52	.07	1.31	.42	.03

^{a,b}Means in same column with different superscripts differ ($P<.05$).

TABLE 4A. DRY MATTER OF FRESH AND ENSILED SORGHUMS AT HARD DOUGH STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	38.7	33.7	41.4	34.9	45.0	47.3
	Ensiled	35.7	29.6	38.5	34.7	44.7	45.1
	MSE	.82	7.27	2.48	.01	.06	2.56

TABLE 5A. NEUTRAL DETERGENT FIBER OF FRESH AND ENSILED SORGHUMS AT 50% ANTHESIS STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	53.8^{b}	54.2^{b}	58.9^{d}	60.5	58.5	60.8
	Ensiled	$65.9^{a,c}$	65.6^{a}	62.8^{c}	63.8	62.2	62.8
	MSE	3.01	.42	.02	1.15	4.75	2.36
Ratoon							
	Fresh	54.0	50.5^{b}	59.5	59.3	58.9	60.8
	Ensiled	55.5^{d}	59.1^{a}	61.0	62.1	61.2	61.3
	MSE	.57	2.97	3.42	1.66	2.24	1.77

[a,b] Means in same column with different superscripts differ ($P<.05$).

[c,d] Means in same column with different superscripts differ ($P<.01$).

TABLE 6A. NEUTRAL DETERGENT FIBER OF FRESH AND ENSILED SORGHUMS AT SOFT DOUGH STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430 [a]	ATx623 x 74CS5388
Parent							
	Fresh	47.8	48.8	48.2	49.7	41.0	42.8[c]
	Ensiled	53.3	54.9	48.1	50.4	40.4	42.0[e]
	MSE	27.53	10.58	1.94	1.30	.21	3.42
Ratoon							
	Fresh	53.5	48.9	52.5	49.4[e]	55.6[c]	54.9[b]
	Ensiled	55.5	52.7	53.7	53.5[d]	58.8[b]	55.3[d]
	MSE	.36	.29	1.41	.25	.58	1.17

[a] Means between fresh states, and between ensiled states in same column differ (P<.01).

[b,c] Means in same column with different superscripts differ (P<.05).

[d,e] Means in same column with different superscripts differ (P<.01).

TABLE 7A. NEUTRAL DETERGENT FIBER OF FRESH AND ENSILED SORGHUMS AT HARD DOUGH STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	48.3	48.4	39.4[b]	46.5	41.0	44.1
	Ensiled	53.3	52.6	47.6[a]	45.5	37.9	40.3
	MSE	.07	12.53	5.16	16.11	1.54	13.08

[a,b] Means in same column with different superscripts differ (P<.05).

TABLE 8A. ACID DETERGENT FIBER OF FRESH AND ENSILED SORGHUMS AT 50% ANTHESIS STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio[a,b]	Wray	ATx623 x Rio[a]	ATx623 x Wray[a]	ATx623 x RTx430	ATx623 x 74CS5388[a]
Parent							
	Fresh	34.8[d]	35.3	37.6	39.2	36.5	37.8[f]
	Ensiled	39.6[c]	39.6	38.2	39.5	38.1	38.7[e]
	MSE	.56	.13	.86	1.69	.83	.01
Ratoon							
	Fresh	30.3[d]	29.1[f]	34.0[d]	34.2[f]	34.8	34.8[d]
	Ensiled	33.8[c]	37.1[e]	38.2[c]	39.7[e]	38.2	38.9[c]
	MSE	.27	.90	.50	.26	.93	1.06

[a] Means between fresh states differ ($P<.05$).

[b] Means between ensiled states differ ($P<.01$).

[c,d] Means within harvest in same column with different superscripts differ ($P<.05$).

[e,f] Means within harvest in same column with different superscripts differ ($P<.01$).

TABLE 9A. ACID DETERGENT FIBER OF FRESH AND ENSILED SORGHUMS AT SOFT DOUGH STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430 [b,c]	ATx623 x 74CS5388 [a]
Parent							
	Fresh	30.3	32.5	31.6	32.2	25.4[d]	27.6
	Ensiled	30.9	34.2	28.6	30.4	24.0[e]	25.0
	MSE	5.01	6.60	1.03	.96	.08	.77
Ratoon							
	Fresh	31.0[e]	28.6	29.7	29.2[e]	31.5[g]	30.2[e]
	Ensiled	34.2[d]	32.8	32.7	33.9[d]	36.3[f]	34.3[d]
	MSE	.05	.23	1.38	.63	.11	.66

[a] Means between ensiled states differ (P<.05).

[b] Means between fresh states differ (P<.01).

[c] Means between ensiled states differ (P<.01).

[d,e] Means in same column with different superscripts differ (P<.05).

[f,g] Means in same column with different superscripts differ (P<.01).

TABLE 10A. ACID DETERGENT FIBER OF FRESH AND ENSILED SORGHUMS AT HARD DOUGH STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	30.4	29.7	26.7	30.5	26.6[a]	28.5[a]
	Ensiled	32.8	33.9	29.8	29.0	22.4[b]	24.7[b]
	MSE	2.68	2.09	.78	5.48	1.05	.93

[a,b] Means in same column with different superscripts differ (P<.05).

TABLE 11A. ACID DETERGENT LIGNIN OF FRESH AND ENSILED SORGHUMS AT 50% ANTHESIS STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	3.3	3.7	3.7[b]	3.8	3.6[b]	3.6
	Ensiled	4.5	4.4	3.8	4.4	4.4[a]	5.0
	MSE	.12	.03	.05	.19	.03	.33
Ratoon							
	Fresh	3.8	3.3	4.3[a]	3.8	4.3	4.6
	Ensiled	3.2	3.5	3.8	4.0	4.5	4.7
	MSE	.77	.19	.15	.38	.13	.24

[a,b] Means in same column with different superscripts differ (P<.05).

TABLE 12A. ACID DETERGENT LIGNIN OF FRESH AND ENSILED SORGHUMS AT SOFT DOUGH STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	4.1	4.3	6.2	5.1[c]	3.2	3.4[b]
	Ensiled	4.3	4.9	5.0	4.9	2.9	3.2
	MSE	.03	1.12	.25	.16	.62	.30
Ratoon							
	Fresh	3.7	3.7	4.4	4.1[d]	4.4	4.3[a]
	Ensiled	3.5	3.4	2.6	4.2	4.5	4.3
	MSE	.22	.14	2.26	.13	.05	.10

[a,b] Means in same column with different superscripts differ (P<.05).

[c,d] Means in same column with different superscripts differ (P<.01).

TABLE 13A. ACID DETERGENT LIGNIN OF FRESH AND ENSILED SORGHUMS AT HARD DOUGH STAGE OF MATURITY (%)

Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
		Type					
Parent							
	Fresh	5.6[a]	5.8[a]	5.4	5.5	3.3	3.7
	Ensiled	4.1[b]	4.0[b]	5.1	5.2	2.9	3.3
	MSE	.14	.14	.40	.54	.26	.04

[a,b] Means in same column with different superscripts differ (P<.05).

TABLE 14A. ASH CONTENT OF FRESH AND ENSILED SORGHUMS AT 50% ANTHESIS STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	1.9	1.6	2.7[a]	2.8	3.1	3.3
	Ensiled	2.2[d]	2.1[b]	2.5	2.8[d]	3.0	3.0
	MSE	.05	.06	.04	.002	.10	.09
Ratoon							
	Fresh	2.2	2.1[b]	2.3[b]	2.9	3.3	3.0[b]
	Ensiled	3.1[c]	3.2[a]	3.3[a]	3.6[c]	4.0	4.0[a]
	MSE	.08	.03	.06	.05	.10	.07

[a,b] Means in same column with different superscripts differ (P<.05).

[c,d] Means in same column with different superscripts differ (P<.01).

TABLE 15A. ASH CONTENT OF FRESH AND ENSILED SORGHUMS AT SOFT DOUGH STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	2.0	2.7	3.1	2.8	2.4[b]	2.7
	Ensiled	2.0	2.7	3.1	3.1	2.7[d]	2.9
	MSE	.06	.005	.10	.21	.25	.25
Ratoon							
	Fresh	3.0	2.7	2.7	3.1	4.0[a]	3.6
	Ensiled	4.0	3.4	2.1	4.0	5.0[c]	4.2
	MSE	.004	.36	1.39	.06	.12	.28

[a,b] Means in same column with different superscripts differ (P<.05).

[c,d] Means in same column with different superscripts differ (P<.01).

TABLE 16A. ASH CONTENT OF FRESH AND ENSILED SORGHUMS AT HARD DOUGH STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	3.1	3.6	2.6	2.8	3.6	3.5
	Ensiled	4.7	5.3	3.5	3.3	3.4	3.3
	MSE	.55	1.22	.07	.25	.06	.13

TABLE 17A. IN VITRO DRY MATTER DIGESTIBILITY OF FRESH AND ENSILED SORGHUMS AT 50% ANTHESIS STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	75.5[c]	74.4	73.1[c]	71.7	73.8	72.4[a]
	Ensiled	67.9[d]	67.5	65.4[b,d]	67.5	71.1	69.4[b]
	MSE	.77	1.86	.33	3.96	1.46	.29
Ratoon							
	Fresh	75.0	76.3	70.7	71.7	71.1[a]	69.5
	Ensiled	76.0[c]	73.8	70.5[a]	69.0	69.1[b]	69.0
	MSE	8.67	2.04	.60	6.00	.25	1.42

[a,b] Means in same column with different superscripts differ ($P < .05$).

[c,d] Means in same column with different superscripts differ ($P < .01$).

TABLE 18A. IN VITRO DRY MATTER DIGESTIBILITY OF FRESH AND ENSILED SORGHUMS AT SOFT DOUGH STAGE OF MATURITY (%)

		Type					
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	73.7	73.6	71.3	69.4	76.9	75.0
	Ensiled	73.5	69.2	70.6	69.7	78.2[c]	76.7[c]
	MSE	6.43	5.81	.51	2.21	3.95	3.05
Ratoon							
	Fresh	76.5	77.0	73.2	74.6	72.5[a]	73.0
	Ensiled	72.7	74.0	71.6	69.8	68.4[b,d]	70.2[d]
	MSE	4.82	5.69	3.77	5.00	.17	.97

[a,b] Means in same column with different superscripts differ ($P<.05$).

[c,d] Means in same column with different superscripts differ ($P<.01$).

TABLE 19A. IN VITRO DRY MATTER DIGESTIBILITY OF FRESH AND ENSILED SORGHUMS AT HARD DOUGH STAGE OF MATURITY (%)

				Type			
Harvest	State	Rio	Wray	ATx623 x Rio	ATx623 x Wray	ATx623 x RTx430	ATx623 x 74CS5388
Parent							
	Fresh	74.2[a]	73.2	77.0[a]	72.6	78.9	77.2
	Ensiled	70.2[b]	70.6	70.1[b]	71.1	78.3	76.9
	MSE	.83	10.79	3.04	.86	1.12	.16

[a,b] Means in same column with different superscripts differ (P<.05).

TABLE 20A. ORGANIC ACIDS AND ETHANOL INTERACTIONS

	Sorghum silage		
Variable	Type * maturity	Type * harvest	Maturity * harvest
	Level of probability		
Lactic acid	NS	.01	.01
Acetic acid	.01	NS	.01
Ethanol	.01	.01	NS

VITA

Manuel Cipriano Heredia Concha, son of Mr. Cipriano Heredia C. and Mrs. Elena Concha de Heredia, was born December 20, 1950 in Barinas, Barinas state, Venezuela. He graduated from the "Liceo San Jose", Los Teques, Miranda state in July, 1967. In September, 1967 he enrolled at the "Universidad Central de Venezuela", Maracay, Aragua state. He graduated as "Medico Veterinario" in July, 1975 at the same institution. He worked privately as an extension specialist until May, 1979, when he entered to the Agriculture Department in Barinas as Livestock Coordinator. He married Maria Elena Manrique in October, 1978. In August, 1982, he enrolled at Texas A&M University in pursuit of a Master of Science in Beef Cattle Nutrition and Production. During the last two years, while completing the degree, he worked under Dr. Lowell M. Schake.

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